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THE MEXICAN ZODIAC.

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(*With a Tinted Plate.*)

In the year 1790 a large stone Zodiac was discovered in the great square of Mexico, buried underground, amongst other ruins occasioned by the devastations of the Spanish conquerors. Gama, the Mexican astronomer, who has written on the subject, Humboldt, and several others, have published drawings of this remarkable relic, but none of them sufficiently complete in their details to serve the purposes of a critical and philosophical inquirer. A mere inspection of our plate will show that an artist would find the delineation of such an object an extremely laborious and difficult task, and without the aid of photography, a reliable copy would, in all probability, not have been obtained. The plate engraved to illustrate this paper is a reduced *fac simile* of a photograph about twelve inches in diameter, and it will be found to exhibit with distinctness the various symbolical objects which the original sculpture contains.

This Zodiac was carved at Tenantitlan out of a mass of finely porous basalt—a rock very common in the country—and was taken to the city of Mexico. On reaching the quarter of Xoloc, it broke from its bearings, and was precipitated into the lake, when the High Priest and many others were drowned. Being rescued from the water, it was transported to the temple of Huitzilopochtli, and its inauguration celebrated by awful sacrifices of prisoners captured in war. These sanguinary scenes took place in 1512, a few years before the arrival of Cortez and his companions.

The outer circle of the Zodiac is eleven feet eight inches in

diameter. Our engraving represents a full-face view, and consequently cannot display a slightly ornamented rim seven inches deep. This rim is, however, indicated by the shadow at the bottom, which the reader will observe. In order to understand the symbolical representations, it is necessary to remember that the Mexican year was divided into eighteen months of twenty days each, each month being named after some incident, or natural object, as will be presently explained.

The months were divided into weeks, not of *seven*, but of *five* days each, and the days of the month were designated by words signifying a sea animal, the wind, a house, a small lizard, a serpent, death, a deer, a rabbit, water, a dog, an ape, twisted grass, a reed, a jaguar, an eagle, a bird, the motion of the sun, silex or flint, rain, and a flower. The cardinal points were designated in the same singular method. Their first point was in the *east*, and represented by a cane, west was named a house, north a flint, and south a rabbit. Having made these preliminary remarks, we shall proceed to describe the circles of the Zodiac.

The several rings are nearly circularly drawn, but the bottom so-called "ray" is not equi-distant to the rays on either side of it.

The face in the centre is supposed to represent the sun. In the forehead are two circular bodies (all circles, dots, or ovals are intended for digits) having between them a figure with three curves, the sign of II Acatl (reed). This means the Reed, or thirteenth day of some month in the second year of the Mexican cycle of fifty-two years. From two circles, probably meant for ears, drop two ovals, containing nine circles and ovals in three lines, and one underneath, = 20, which is the number of days in the month. Underneath the chin, and on each side of the elongated tongue (symbol of speaking), there are six dots and ovals.

Within the next or second large circle are, first, four parallelograms, supposed to be in allusion to the belief that the sun had died four times. The first to the right represents IV Ocetotl (jaguar), answering in this place to our 22nd of May, in the first year of the cycle; the second, IV Atl (water); the third, IV* Quiahuitl (rain), 26th July; the fourth, Ehecatl (wind). These four symbols are also said to represent the four weeks of a month. The two lateral figures denote claws, said to be symbolical of two ancient astrologers, man and wife, who were represented as eagles or owls.

* The exact meaning of the numeral IV, as applied in these cases, is not quite understood.

The inverted V, called by Gama a triangle, at the top of the head, indicates the first and last day of the month. On the right is an oval symbol, which may be Echatl (wind); the one on the left probably represents Tepactli (silex). Underneath the tongue are two squares, each containing five indications = 10, which may belong to Ollin, or motion of the sun; to its right are circles and a head, or I Ozomatli (ape), 22nd of June, in the 26th year of the cycle; to the left is a figure called I Quiahuatl (rain), 22nd of March in same year of the cycle.

The third circle contains twenty divisions, representing, by Zodiacal signs, the twenty days of the month of the priests, which differed from the common month. These are read from the left, beginning under the left point of the upper ray. The signs of Sea Animal, Wind, House, Small Lizard, Serpent, Death, Deer, Rabbit, Water, Dog, Ape, Twisted Grass, Reeds, Jaguar, Eagle, Bird, Motion of the Sun, Silex, Rain and Flower. House, Rabbit, Reeds, Silex, stood in the middle of each small period of five days forming the weeks. A repetition of thirteen times of the above four would be equal to fifty-two, or the cycle of years.

Each of the eighteen months (not represented in this Zodiac) had its name, already alluded to, from some natural objects characteristic of the particular season, or from some festival or employment, as To glean. Trees bud. Victims flayed alive. Vigils of the priests. Grand Penitence. Garlands of Maize tied round the necks of the Idols. Food of Maize. Festival of Young Warriors. Festival of Old Warriors. Little Festival of the Dead. Great Festival of the Dead. A Broom-cleansing of Canals. A Parasitic Plant. Festival of Rural Divinities. Sacred Flamingo. Standard of one of the Principal Gods. Descent of Water and Snow.

In the fourth circle are a number of squares, each containing five indications = 190. It has heretofore been presumed that the four angular objects called rays covered twelve squares (but there is too much room for the said twelve squares); if so, the fifty-two squares, each containing five indications, would give 260, or the period of twenty-one series of thirteen days; however, I only make 190. I may observe that outside the 190 indications there are 70 of a doorway appearance; adding these two numbers, we get 260, which fact may be worth noticing.

The large angular objects, said to be sun's rays, may, I think, rather represent the four cardinal points. There are also four smaller angular sub-divisions, and four of a square form (somewhat like the sign for Tepactl or silex), making in

all sixteen divisions, which may have to do with the Mexican division of the day into sixteen parts.

Speaking of the outer circles, Gama says, "The external zone consists, except at the extremities, of a symbol twenty times repeated, which may represent the Milky Way. The waving lines are probably meant for clouds." Others suppose them to be symbols of mountains, in which clouds and storms originate; whilst Gallatin thought them to be altogether ornamental.

I will now examine this portion of the Zodiac. Between the large and small rays there are six sets of ten indications, and two of five (something like Acatl, or reeds) = 70, which number has been already referred to. Out of the centres of the six sets rise figures, called by Gama "*rafagas ó luces*," which may mean plumes of feathers. These figures have squares with five indications each = 30, twelve of these would be = to 360. Then there are door-way indications, each of three, = 18, which may have to do with the eighteen months of the Aztec year.

Then follow the twelve series of the waved symbol (supposed by Gama to represent clouds and mountains), and underneath twelve open spaces of fours, = 48. The whole figure looks to me like the symbol Atl, or water. Did the Aztecs suppose that the world, as they knew it, was surrounded by water? One of their expressions was, "All the round world is but a sepulchre." Solis observes that one of their principal idols was seated in a chair, which was on a blue globe, which they called heaven. Out of this circle springs the symbol of the year XIII Acatl, or reeds (the twenty-sixth of the cycle).

We now come to the symbol on the outer edge, ten times repeated on each side, = 20. In the upper portions are band-like figures (which may be reeds), and probably have reference to the tying up, or completion of the cycle every fifty-two years. Further on are two more of these symbols, and in the lower portions two more partially covered, = 24. The twenty symbols have ten indications each, = 200. There were great feasts at every 200 and 300 days; but the symbols at the top have forty indications, and if the lower ones contained the same number, we should have 260 indications, or the number of days in the year of the priests, which had 100 days less than the solar year. Gama supposed this to be the symbol of the Milky Way; but it strikes me rather to represent plants or flowers. The first Spaniards called them tufts of flowers. I find the symbol to bear a great resemblance to that of the 20th, or last day of the month Xochtl, or Flower. May we suppose the Aztecs conceived that this was to represent the outside of

the circular plane of the world, and that it was an Elysium of green pastures and forests, the "happy hunting grounds" of the Indians of the north?

Pointing to XIII Acatl, the square symbol at the top of the plate, are two angular figures, which Gama says are merely indications of XIII Acatl. At their bases are objects like pillars, each supporting six rings or circles, = 12. Can this arrangement indicate the twelve solar months of the year?

In all this region, indeed, all round what I call the flower symbol, there are a series of diagonal lines, which may represent the sun's rays.

At the bottom are two lizard-looking figures; they have in Gama's drawing 86 dots and 104 lines, = 190. Gama calls the two profiles of heads at the bottom Tohnalteuhtli, which is the first name on the list of nine Lords of Night.

In a narrow circle near the edge are some sixty-five dots on each side, or 130, twice this = 260, the days of the year of the priests. In reference to the number 130, it may be stated here that Gama supposed the stone Zodiac was for six months of the year only, and that there was another for the other six months. He also thought one faced the north and the other the south. In this opinion I do not coincide.

Outside the above-mentioned circle, and running partially down the edge, are a series of oval indications, apparently 31 and 5 on one side, 32 and 5 on the other, = 73. Now there were 73 cycles of 260 days to form the cycle of fifty-two years, so that these ovals may have to do with this large cycle.

Eight holes, believed to be for gnomons, are found just outside the rim of ovals, and vertical to the surface of the stone. As this is so, I should conclude that the stone, when in position, was laid flat, and not upright, as Gama supposed.

Over the two heads (in Gallatin's drawing) are series of 24 and 21 indications, = 45 (twice 45 = 90 × 4 = 360). I make out 180 indications; this doubled, would give 360 for the days of the year, not including the five interculary days.

Gama observes that "we have delineated on this stone the dates of the five principal positions of the sun, from the vernal to the autumnal equinox. Three of these, the two transits of the sun by the Zenith (22nd May and 26th July), and the autumnal equinox (22nd September), are the Mexican days on which these phenomena occurred in the first year of the cycle (I Tochtli); and the two others, the vernal equinox (22nd March), and the summer solstice (22nd June), are the

Mexican days on which these two occurred in the XIII Acatl." He also informs us that this Zodiac is a true meridional clock, by means of which the Mexicans knew the eight intervals of the artificial day; four for the morning, and four for the evening, from the rising to the setting of the sun, as shown, most probably, by the shadows of the eight gnomons fixed *in the holes in* the circumference.

In the second lot of presents sent by Montezuma to Cortez, were two circular plates, one of gold, the other of silver, as large as carriage wheels. One, representing the sun, was richly carved, or in relief, "with tufts of plants and animals." It was valued at nearly £60,000. The silver wheel weighed some fifty lbs. At Tlascalá, with other presents from Montezuma, were "embossed gold plates" (Zodiacs). In a pond in Guatemozin's garden, the soldiers of Cortez found "a sun, as it was called;" this was one of the Zodiacs, or Aztec calendar wheels. Benvenuto Cellini saw some of these things, and was filled with admiration. They all went into the melting-pot centuries ago; but if they had been preserved, they might have assisted us in deciphering with accuracy the stone Zodiac which we have endeavoured to describe.

No pains have been taken to preserve the stone Zodiac from injury. It is now stuck in the wall of the tower of the cathedral, and has been exposed to the action of the weather and other causes of injury ever since its discovery. Thus some of the details we have described can with difficulty be made out at the present time; but by referring to the engraving illustrating Gama's rare work, published in Mexico at the beginning of this century, much aid is given. This drawing, though, as before remarked, not complete, was made when the Zodiac was in better condition than it has been for many years.

As very few Europeans have studied the curious subject of the astronomy of the Red Man, whose peculiar form of civilization reached its highest development, under diversified conditions, in the countries of Mexico and Peru, it may seem surprising that so much scientific knowledge should be imputed to them, as is involved in the descriptions of the stone Zodiac.

There can, however, be no doubt that the Red race arrived at a very considerable acquaintance with celestial phenomena. In Grave Creek Mound, Western Virginia, stone tubes have been found, supposed to have been intended for viewing the stars, after the manner practised by early oriental nations.

In ancient Mexico, where science was more advanced, the causes of eclipses were known. The learned men gave an

account of the great comets, especially the one of 1489. They also had a system of constellations, and were acquainted with four of the planets, including Venus. Gama describes an arrangement of three masses of stone at Chapultepuc, so arranged as to indicate east and west, and to show by shadows the exact time of the rising and setting of the sun at the period of the equinoxes and solstices, and the true mid-day during the year. In a late examination of the Pyramid of Xochichalco, or Hill of Flowers, an apartment was discovered, having a hole in its roof leading up to the summit of the pyramid, and so placed that it permitted the sun's rays to enter, and to fall, as tradition says, upon an altar at the exact date of the sun's crossing the tropics.

In Central America, the Red race constructed calendars bearing considerable resemblance to those of the Mexican, and in New Granada the Muisca natives engraved calendars on polished stone, usually in a pentagonal form, and their priests made lunar observations to regulate the division of time, their year consisting of twenty lunar months. Many details concerning them and kindred subjects will be found in my work on South American antiquities.* In Quito the Caranes conquered the ancient Quitus about 1000 A.D., and their chiefs, known as the Scyris, erected stone columns, which were used to observe the solstices, and regulate the solar year. They are said to have had twelve pilasters placed round their chief temple, serving as so many gnomons, to show the first day of each of their twelve months. These were most probably their own invention, and existed before their conquest by the later Incas of Peru. In Chile, the Araucanos distinguished planets from stars, took note of solstices and equinoxes, and grouped the stars into constellations. Their year was solar, consisting of 365 days. They also had a lunar year of twelve moons of thirty days each.

The Peruvians do not seem to have made as much progress in astronomy as the Mexicans; but their mechanical arrangements were highly curious. Eight cylindrical towers were erected to the east, and eight to the west of Cuzco. Each series of eight consisted of six large towers, in a straight line, with two smaller ones in the centre. The lines of towers were north and south, so that an observer stationed, say in the west group, could, by looking through the spaces, observe the sun rise between the opposite spaces between the towers of the east group. Some writers say there were twelve towers

* *Antiquarian, Ethnological, and other Researches in New Granada*, etc., by Wm. Bollaert. Trübner and Co.

on each side; but in a gold calendar described by me in the work alluded to, the number of towers in a row is eight. These contrivances are believed to have indicated the solstices and other celestial phenomena. To discover the days of the equinox, they erected a stone column in an open area in front of their temple. This column was in the centre of a circle, and a line was drawn from east to west, and when the noon-day shadow of the pillar crossed this line at particular points, the equinoxes had arrived.

In January, 1864, Mr. D. Forbes presented me with a drawing of a small human figure in silver he had discovered in an ancient tomb in Bolivia.

The annexed woodcut represents the upper portion of this figure, and it will be seen that it is that of a man observing some celestial object through a hollow tube applied to the left eye. This is the first *undoubted* indication of a telescope tube being used in the new world, and gives probability to the supposition that those found in Grave Creek Mound were designed for a similar purpose.

GEOLOGICAL WORK OF FROST AND FIRE.*

THE craft of reviewing has got into deplorable discredit in this country through the very shallow, or very untrustworthy opinions of books, or other productions, that too often occupy the pages of publications pretending to intelligence and impartiality. Some works are indeed difficult to describe fairly, and Mr. J. T. Campbell comes before us with two very beautiful and valuable volumes, in which merits and defects are alike conspicuous, so that it is far from easy to speak of them as they deserve. Sir Roderick Murchison, an excellent judge of such matters, speaks highly of *Frost and Fire*, and some critics have overwhelmed both the book and its author with preposterous praise. The truth, as we apprehend it, is that Mr. Campbell is a shrewd observer, and an admirable draughtsman of certain physical appearances which our globe presents, but his stock of scientific knowledge, though greater than he takes credit for, is by no means extensive, and he lacks the art of sustaining a pleasing, or methodical style. We should, therefore, describe his book as a collection of a hundred and seventeen beautifully executed and remarkably interesting sketches, chiefly illustrating the geological work performed by ice, and water set in motion by heat, accompanied by rambling, often crotchetty, and frequently clever descriptions of what he has seen, and how he interprets it. Most persons will, we think, find it tiresome to read his volumes through; but no one of scientific taste can fail to gain both pleasure and information from their pages. To the beginner they offer many shrewd hints and valuable suggestions, and the experienced geologist will welcome so large a collection of data of the highest importance in interpreting the history of our globe.

The fundamental idea of Mr. Campbell, and it is a good one, is that work, whether human or geological, is done with tools, and that tools leave their marks behind them wherever they have been employed. In the natural world two very important tools are, in his phraseology, "Frost and Fire," the glacier being the grandest exemplification of the one, and the volcano of the other. He does not take sufficient notice of the enormous amount of work performed by less striking agency, such as the quiet flow of rivers, the fall of rain, and the action of the air, hence his philosophy is incomplete, and his account of the modifications which terrestrial strata have experienced, wants the charm of due proportion in its several

* *Frost and Fire, Natural Engines, Toolmarks and Chips.* With Sketches taken at Home and Abroad, by a Traveller. 2 vols. Edmonston and Douglas.

parts. Such remarks, however, indicate his omissions, and we always deem it an ungracious thing when any one renders a decided service to science, to descant upon what he has left undone, instead of recognizing with becoming thankfulness what he has performed.

In an early part of Mr. Campbell's work some clever experiments are recommended as exhibiting to the eye the nature of the air and water currents which affect our globe. He recommends that a common aquarium, or oblong fish tank, shall be half filled with clear water, and placed in the sun. At one end a few lumps of rough ice are to be floated, and a black stone sunk at the other. When the water has settled, milk is to be poured gently on the ice at the rate of an ounce to each gallon of water in the tank. The sun's heat is absorbed by the black stone, and communicated to the adjacent water, producing an ascending current, while at the other end of the tank a descending current results from the cooling action of the ice. The milk, which if carefully poured in, mixes very slowly with the water, forms clouds whose movements indicate the currents and the amount of force by which they are impelled. "Cloud forms," says Mr. Campbell, "are copied with marvellous fidelity in this water toy, and, because the movement is very slow, they are easily seen and copied. But the tank gives a section of air as well as water. The miniature sea has an atmosphere, and the same forces work both engines. Let a bit of smouldering paper, tinder, rope, touchwood, or any such light combustible fall on the ice-raft, and cover the tank with a sheet of glass to keep in the smoke." By this means imitations of all sorts of natural clouds may be produced.

The same tank may be made to illustrate the movements of water about to freeze, when the apparatus is placed in a cold atmosphere. At one corner Mr. Campbell hangs a small thermometer, just dipping into the water; at the opposite corner he places another thermometer, with its bulb reaching the bottom, and capable of being elevated or depressed without making much disturbance. On some ice, floating near the centre of the water surface, he paints some lamp-black, sinks a globular block-tin bottle, filled with boiling water and corked, near the thermometer which touches the bottom, and covers one side of the tank with a screen of thin paper. When the ice begins to melt, the lamp-black begins to move. "If it is warmed by the sun, a dark revolving column sinks slowly down. But beneath the ice are layers which contain intricate patterns of curved lines of black, which bend and move slowly, but keep near the ice." "When a water-bottle, filled with hot water, coloured with lamp-black, is sunk through an ice dome without the stopper,

a warm dark column rises up like the spirit whom the Arabian fisherman let out of the copper vase. . . . . When the water is hot, a thing like a round-headed mushroom grows rapidly out of the neck, and takes all manner of strange shapes."

Experiments of this kind admit of indefinite variation. They can be performed with trifling expense, and are excellently adapted to explain the nature of actions by which climate is affected, and the superficial strata of the earth exposed to influences that modify their form.

Mr. Campbell's illustrations of "river marks" are very instructive, but he chiefly notices the violent action of tumbling streams. He does not omit quieter operations, as his clever sketch of Thames meanderings shows; but his favourite river theme is the mountain torrent, with its mark ⌊ in the rock which it cuts through. After mentioning many instances of this sort of action, he observes that "at the Devil's Bridge, near Aberystwith, a stream has sawed a groove in the blue slate. It is ninety feet deep, and about six wide. . . . . The rivulet has ploughed a groove at the bottom of a curve; it has turned V into Y."

After studying the river marks, the next step is to learn those of large floating ice masses and glaciers; and for students who cannot travel as extensively as Mr. Campbell has done, his sketches will prove an invaluable substitute. The glacier leaves its characteristic tool marks. "Wherever it goes the ice tool grinds; it works broken stones into polished boulders, boulders into mud, fractured rocks into *rôches moutonnées*, and mountain glens into rounded, polished, striated rock grooves, whose ground section is a curve ⌣. When the ice melts, floating chips are left in the groove in their order."

Mr. Campbell gives a good description of the various tool marks left by moving masses of ice. The ice may polish rock surfaces; it may mark them with striæ, or scratch them with sand lines, or score them, or groove them, or make deep grooves, or hollows, or glens, or in passing over rocks that wear unequally, it may give them a bossy or mammillated form, and thus make *rôches moutonnées*. Very characteristic sketches of these several effects are given in the two volumes of *Frost and Fire*.

No geologist doubts that great masses of floating ice, such as can now be studied in Polar regions, and huge glaciers, of which Switzerland, Norway, and other localities afford good specimens, were the kind of tools which in former ages did very extensive and important work in fashioning the surface of the globe. In many cases the "tool marks" are distinct enough to point clearly to their origin; but when certain

observers and writers go beyond the definite information conveyed by such markings, and ascribe to glaciers the function of digging all the gigantic hollows in which the great lakes of Europe and America now repose, we may prefer exercising due caution, and not be too ready to accept explanations which have rather the aspect of overriding a favourite hobby than that of calmly considering all the circumstances that have to be explained. There is a tendency in philosophers to follow a practice common amongst physicians, and to have their pet causes, just as the latter indulge in their favourite remedies. At one time it may happen that patients seeking medical aid are all mercurized, bismuthized, or iodized, according to the fashion of the hour, and in like manner geologists indulge in fiery or watery speculations, sometimes neglecting and sometimes exaggerating the action of any particular agency capable of forming or changing terrestrial rocks. Mr. Campbell is a decided worshipper of the spirits of ice. Within the limits we have indicated we highly esteem his labours, and in taking leave of his *Fire and Frost*, we wish him health and opportunity for further travel, and that he may bring home and publish as valuable a series of sketches as those which will give permanent importance to the work he has just produced.

PHOTOGRAPHY AT GREENWICH OBSERVATORY.

BY THOMAS W. BURR, F.R.A.S., F.C.S., ETC.

THE scientific operations carried on at the Royal Observatory are essentially of a practical and utilitarian character. Originally founded for the especial purpose of the improvement of navigation by the construction of accurate catalogues of stars and tables of the moon, it is highly to the credit of its successive directors that they have never been tempted to a diversion of its resources to objects more immediately attractive and likely to bring them fame and renown as discoverers of fresh heavenly bodies, or other additions to the wonders of astronomy.

It is to this steady devotion to the original purpose of the establishment that we are indebted for the great work of Flamsteed, his *Historia Cœlestis;* for the indefatigable observations of Bradley, and his great discoveries of aberration and nutation; the well-conceived plans and constant labours of Maskelyne, who started the *Nautical Almanack* on its useful career; the instrumental improvements and exact observations of Pond; and last, but not least, the laborious

reductions of all the Greenwich observations for nearly 100 years by the present Astronomer Royal, Mr. Airy, who has himself compiled some excellent star catalogues, who has planned instruments combining engineering and optical science in a way previously unknown, who has introduced the galvanic system for registering observations, and devised an instrument especially devoted to making trustworthy observations of the moon in parts of her orbit inaccessible by meridian instruments—an addition which has resulted in bringing up the tables of the moon to a pitch of excellence apparently leaving nothing to be desired.

In carrying out the determination to adhere to the improvement of the fundamental data of astronomy in preference to all other objects, the directors of our national observatory have evinced the greatest self-denial, and have been compelled to leave to other observatories or to private amateurs the brilliant pursuit of new planets and comets, the attractive subjects of double and variable stars, the glorious revelations of spectrum analysis applied to the heavenly bodies, and even the valuable aid of photography in delineating the features of the sun and moon. There is, however, one application of photography so thoroughly practical in its character that it has been gladly taken advantage of at the Greenwich Observatory, and it is of this interesting process that we now propose to offer some particulars, assisted as we have been by the materials kindly furnished by the Astronomer Royal.

The photographic operations to which we allude are the processes carried on for the continuous self-registration by photography of the indications of the magnetic and meteorological phenomena at Greenwich, which, although among the most valuable of all applications of the beautiful art-science referred to, is yet eminently unobtrusive in character, and for thousands who admire the photographic delineations of the persons they love or esteem, the exquisite scenery of our own or other lands, or the glories of architecture, sculpture, or painting, we can count but a few individuals who comprehend and appreciate the ceaseless working of the photographic records of the magnetic and meteorological instruments at the observatories of Greenwich, Kew, and Oxford; the daily portraiture of the solar spots at Kew, Cranford, and Ely; and the magnificent delineations of the lunar disc and the phenomena of a total solar eclipse, which Mr. De La Rue has produced; as well as the occasional photographic operations of a few other followers of astronomical or physical science.

In utility it is probable that not one of these valuable applications of photography will compare with this automatic registration of phenomena, so delicate in their nature and so

constantly changing, that but for this method of obtaining a perfect and unerring record most of their manifestations would be altogether lost, or if observed at all, it would be at intervals only, and accomplished by an expenditure of labour amounting to drudgery, which might have been better applied.

The science of Terrestrial Magnetism is perhaps not one of the most attractive, and those readers of the INTELLECTUAL OBSERVER who have studied it will doubtless, for the sake of others not familiar with the subject, pardon a few words of explanation as to what we desire to observe, and the instruments employed in observing, with the methods of using them, before we describe the photographic processes forming the principal object of this paper.

Everybody is aware of the directive property of the magnetic needle as used in the mariner's compass, but all may not equally be cognizant of the fact that the direction of the needle is not always and everywhere to the *true* or astronomical north, but varies very considerably from it at various places on the earth's surface; and that even when the variation is determined for any one place at any particular time, this variation is not constant, but is always changing. For instance, at London in the year 1550, upwards of 300 years ago, the needle pointed 11° 17′ E. of the true north; about 1660, rather more than 200 years ago, it had returned to its normal position, and then coincided with the astronomical meridian; after which it began to move westward, attained its greatest deviation of 24° 27′ W. in 1815, and is now slowly returning to the north, its present variation being about 20° 30′ W.

At Paris the variation has undergone nearly the same changes, but at other places, Jamaica for example, it has remained constant. At Liverpool it is almost 1° 30′ greater than at London; at Edinburgh about 2° 5′ greater; at Yarmouth and Dover about 40′ less. In Siberia and some parts of North America the variation is at present towards the east.

In addition to this steady *secular* variation, or *declination*, as it is now termed, there are other alterations of the direction of the magnet constantly progressing. One of these is diurnal, and causes the north end of the needle in our hemisphere to move eastward during the early morning hours; it will arrive at its extreme easterly elongation between 7 and 8 a.m.; it will then begin to move westward, reaching the extreme west point between 1 and 2 p.m., and then returning in an easterly direction. This variation is governed by the solar time at every place, and is clearly traceable to the sun's position, which produces another fluctuation in these diurnal changes, whereby for half the year, that is, from spring to autumn, the

amount of the diurnal variation is greater than in the winter half of the year. In southern latitudes the variation is westerly in the morning and easterly in the afternoon, but it follows the law of local time, and the annual inequality is also coincident with ours, although it is winter there; and the same law prevailing in the tropics, where the temperature varies but little, proves that, although produced by the sun's influence, it is not an effect of heat.

There are also sudden irregularities known as magnetic storms, which produce perturbations of greater or less magnitude simultaneously over the globe, and which have occasionally been found to be contemporaneous with the exhibition of brilliant auroræ on the earth, or sudden alterations of the surface of the solar disc. The labours of General Sabine have made us acquainted with the fact that these perturbations have the same periods for their maxima and minima as the number of solar spots as determined by Schwabe, both the classes of phenomena having a cycle of about ten years and a quarter, and this solar spot period also influences the whole of the magnetic elements.

We are indebted to the researches of the late Professor Gauss, of Gottingen, for the foundation of our present position in magnetic science. He, co-operating with the celebrated Humboldt about thirty-five years ago, formed an association for simultaneous observation at various continental stations, and himself devised the methods of observing and the instruments still used. He showed that the position of the needle at any time is the result of three forces acting together on the magnet, and that these three forces are the declination, the inclination, and the intensity of the force. The first of these elements is observed by the declination magnetometer, but the two last are not observed directly, but deduced from the variations of the two components, the vertical force and the horizontal force, which conjointly produce the direction of the magnet. The instruments used for this purpose are the dip or balance magnetometer, and the bifilar magnetometer.

An ordinary magnet will in most parts of the Northern Hemisphere have the marked end depressed, and as we proceed northward this depression increases, until we reach points where the needle becomes vertical. Thus, in 1831, Sir James Clarke Ross, in latitude 70° 5′ 17″ N. and longitude 96° 45′ 48″ W., found the dip to be 89° 59′, within one minute of the vertical; and as in the Southern Hemisphere the opposite end preponderates, the same observer in 1841 found an inclination of 88° 36′ in latitude 75° 22′ S. and longitude 161° 48′ E. These points are, it will be seen, by no means

coincident with the poles of the earth's axis, neither do they indicate the points of greatest intensity in the magnetic force, which is nearly three times as great in some parts of the earth as in others. The dip, like the declination, is subject to secular, annual, and diurnal variations, but our limits will not allow us to enter upon the details. It may, however, be mentioned that at London in 1720 the dip was 74° 42′, and in 1830 69° 38′. It is now about 68°, so that it continues diminishing.

In 1836, principally by the exertions of Humboldt, the British Government consented to co-operate in the formation of magnetic observatories, and accordingly established and equipped those at Toronto, St. Helena, the Cape of Good Hope, and Hobart Town. The East India Company established four more in their territories, while magnetic and meteorological departments were added to the observatories of Greenwich and Dublin, and an expedition to the Antarctic Seas was sent out under Sir J. C. Ross, to obtain corresponding observations in high southern latitudes. Some of these observatories were kept up for a limited period only, but others remain in full operation; and to the accumulated mass of observations thus procured, as reduced and discussed by General Sabine, we are now indebted for an immense increase of our knowledge of terrestrial magnetism and its laws.

The present Astronomer Royal has always taken a deep interest in magnetism, and is himself one of our best authorities on the subject, and in the year 1837 he became anxious that our national observatory should take part in the efforts then making to improve the science. Accordingly, at his request, an additional piece of ground was enclosed in the observatory domains, and in the following year the magnetic observatory erected. It is built of wood, and fastened with wooden pins, the metal iron being carefully excluded, except in the case of a portion of a stove and those parts of the clocks and instruments where it is absolutely necessary. The position of the building is about 170 feet from any other part of the observatory, and 34 feet from the nearest shed or erection of any kind. It is in the form of a cross, originally 40 feet in each direction, by 12 feet wide and 10 feet high; but the northern arm of the cross has lately been lengthened 8 feet. From the exterior of the observatory grounds the building is easily recognized, as in front is placed the tall mast used to collect atmospheric electricity, and conduct it to the various pieces of apparatus placed in the window of the northern arm of the building. The remainder of this arm forms the computing room of this department of the observatory. The instruments were placed in the remaining three arms of the

observatory, and, as to the magnetic department, are three in number. We say "were placed," for recently a change has been made in their positions, to be referred to presently; but it will be more convenient to describe the arrangements as they existed for many years previously. It has already been stated that the inclination or direction of a magnetized bar can be resolved into two forces acting in different directions, and the instruments used are designed to ascertain the variations from time to time, first in the direction of a needle, free to move in azimuth (that is, E. or W. with regard to the meridian); secondly, the variations in the dip or vertical plane; and thirdly, in the intensity of its horizontal force. The declination magnetometer is used for the first purpose, viz., to measure the variation, or, as it is now termed, the declination of the magnet, and the incessant alterations which are going on in this element. The instrument is placed in the southern arm of the cross-shaped building, and consists of a massive bar magnet two feet long, carried by a stirrup suspended by silken threads with as little torsion as possible, and surrounded by double gilt boxes, having holes covered with glass for the observations, to avoid currents of air, and an oval copper bar or damper to lessen the vibration. At one end of the magnet is a frame carrying a cross of cobwebs, and at the other end a lens, which renders the rays from the cross parallel. In the centre of the room is a transit theodolite, by means of which, directed to the stars through a shutter in the roof, the true meridian can be ascertained, and the readings of the direction in which the cross on the magnet is seen through the lens, as compared with the readings of the circle given by stars on the meridian, will give the amount of the declination at the times of observation. The cross is lighted either by a reflector in daylight or a lamp at night, as may be necessary for the purpose.

The dip or balance magnetometer occupied the western arm of the cross building, and, as its name implies, measures the angle formed by a magnet freely suspended on knife edges, and at liberty to move in a vertical direction. The dip, like the other magnetic elements, is in a state of constant change, some of its more important alterations having already been noticed.

In all ordinary suspended magnets, the dip is counteracted by an increased weight at the other end, and in the balance magnetometer, which is placed nearly at right angles to the magnetic meridian, this inclination is almost counterpoised, the object being not so much to determine the absolute dip, which is done by separate instruments at stated times, as the variation in the vertical force. In order to measure this

change, which requires much more delicate means than the variations of the declination magnetometer, a small plane-mirror is attached a little out of the centre of the bar, which reflects the divisions of a vertical scale attached to the wall of the room, and these reflected divisions are observed with a telescope fixed near the theodolite, the motion of the magnet having been thus much magnified.

The absolute force of the magnet at Greenwich, like the absolute dip, is determined periodically by separate experiments; but the remaining element, or the horizontal force of the magnet, is measured by the third instrument contained in the eastern arm of the room, and called the bifilar magnetometer. It consists of a magnetized bar, like the other instruments, which is suspended by two parallel sets of silk threads. If the strings and the magnet were in the same vertical plane the whole system would remain at rest; but the force of torsion is ingeniously brought into play to measure the horizontal force of the magnet. For this purpose the suspending skeins of silk pass under two pulleys, attached to a plate turning on a graduated circle with much friction, by moving which the magnet suspended to the circle is twisted out of the meridian to a position nearly at right angles with it. The force of torsion is, therefore, now acting antagonistically to that of the magnet, which endeavours to regain its normal bearing; and as the torsion force is constant, and that of the magnet subject to ceaseless variations, the magnet is always taking up fresh positions, and these angular changes can be connected mathematically with the forces producing them, and the share of the magnetic force in them deduced by calculation. The bar carries a small mirror, as in the last-described instrument, by which the reflection of a fixed horizontal scale is observed in another telescope precisely as with the balance magnetometer.

In the original arrangements of the observatory, all these instruments were observed every two hours, and on certain days in the year at every hour, and even more frequently still, which, in addition to other work of the department, fully employed Mr. Glaisher and several assistants, and was monotonous and wearisome in the extreme, as, unlike the astronomical assistants, bad weather brought them no relief of their labours. Even assuming that the observations were punctually made, it is obvious that many most important phenomena might escape notice during the two hours' interval, especially in the case of magnetic storms, and some system of continuous and automatic registration became a great desideratum. It was obvious that no mechanical arrangement, such as the movement of pencils by the magnets, was admissible;

for the finest cobweb would have effectually fettered the delicate motions of these instruments, and therefore photography was at once looked to for the required assistance, and to the inventive talents of Charles Brooke, Esq., F.R.S., the eminent surgeon and microscopist, we are indebted for the plan adopted about the year 1846, and which has since been in constant operation for the registration of the magnetic instruments we have described, as well as the barometer and thermometers.

The photographic process employed is a paper one, being a modification of the calotype, in which an invisible trace, produced by the action of light, is subsequently developed by suitable re-agents, and, waiving for the present all details of its preparation, we will first consider the mechanical arrangements of the apparatus. The sheets of paper, when properly sensitized, are wrapped round glass cylinders, which are, in fact, the ordinary glass shades used to protect works of art. Those used are 11½ inches long and 14¼ inches round. Each shade is cemented into a brass cap, having a spindle projecting from the centre. This pin and the hemispherical end of the cylinder rest on friction rollers in the case of a horizontal cylinder, and a wire from the spindle, bent into the form of a winch, rests in a hole in the hour-hand of a strong time-piece, by which it is made to rotate smoothly in twenty-four hours. In the case of a vertical cylinder the time-piece is placed below the glass shade, the arrangement for rotating it on its axis being the same.

After the prepared paper is rolled round the cylinder, it is covered by another shade slightly larger, and the two are made to fit by wet tape round the mouth, and some damp wadding is also placed in the spherical end of the shade to keep the paper moist. The registration of the magnets is effected by allowing a beam of light from a very narrow slit in the copper chimney of a gas-flame placed a little out of the line joining the magnet and the revolving cylinder, to fall on a concave mirror carried by a part of the apparatus, suspending the magnet, and, of course, moving with it. This causes the beam of light to converge nearly on the centre of the cylinder about twelve feet off, where it falls upon a plano-convex cylindrical glass lens, having its axis parallel with the axis of the cylinder, by which the image of the slit is reduced to a neat spot or pencil of light. The magnet moving in azimuth, produces a spot of strong light, which runs along this lens, and, as the paper revolves under it, this light, by its actinic power, produces a continuous line round the cylinder, deviating to the right or left, and thus indicating the horizontal motions of the magnet.

A diagram of the apparatus will render this more intelligible. In the accompanying drawing (Fig. 1) only the

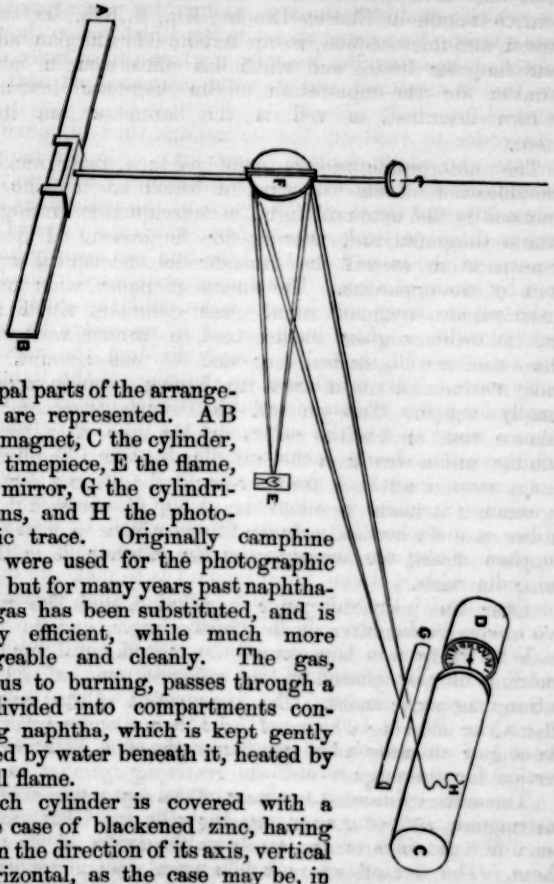


Fig. 1.

principal parts of the arrangement are represented. A B is the magnet, C the cylinder, D the timepiece, E the flame, F the mirror, G the cylindrical lens, and H the photographic trace. Originally camphine lamps were used for the photographic light; but for many years past naphthalized gas has been substituted, and is equally efficient, while much more manageable and cleanly. The gas, previous to burning, passes through a box divided into compartments containing naphtha, which is kept gently warmed by water beneath it, heated by a small flame.

Each cylinder is covered with a double case of blackened zinc, having a slit in the direction of its axis, vertical or horizontal, as the case may be, in front of which is placed the cylindrical lens. The whole course of each beam of light, from the flame to the magnets, and thence to the cylinders, is also enclosed in tubes of blackened zinc, keeping out all extraneous light.

As neither the glass cylinders can be expected to be very perfect in shape, nor to rotate very symmetrically, nor the paper to be always exactly alike in size, the following contrivance to obtain a base line from which to measure the departure of the

curve is used. A separate gas flame is placed, so that its light, reflected by a prism through a small cylindrical lens on the top of the horizontal cylinder, forms another spot of light on it, which remains stationary; and as the paper travels this prints a strong line round the cylinder, which, when the paper is unrolled, becomes the base from which the distance of the curve can be measured, and its value estimated, as next to be described.

In order to read off the indications thus obtained, and translate the photographic curve into ordinary language, observations are made with the theodolite in the old way, four times a day, and these give the value of the indications of the curve at those particular times, from which the value of other distances of the trace from the base line can readily be measured by means of a scale drawn upon pasteboard. The length of the paper being not always alike, and the going of the clock likewise slightly irregular, it is necessary to have a time scale as well, instead of simply dividing the paper into hourly parts. This is effected by shutting off the light occasionally for a few minutes from the cylinder, which, of course, leaves a white spot in the curve, and the interval between two such operations being accurately noted, gives the time equal to a certain length of paper, and to divide this readily an ingenious expedient is adopted. A slip of vulcanized India-rubber is stretched in a brass frame, which, by a screw, will lengthen or contract the slip, and the scale being marked on the India-rubber, it can be altered so as to make its divisions correspond with the value of the period of time measured by two breaks in the curve on the paper.

With respect to the absolute length of the photographic traces, it may be mentioned that a variation of 1° in the declination magnet is measured by five inches on the cylinder, and that a variation of 1000th part of the horizontal force covers about $\frac{1}{4}$ of an inch on the paper, and the same variation in the vertical force about $\frac{1}{3}$ an inch.

The same cylinder is made to record the indications of two instruments, by being so placed that the light from each falls on different sides of it, the base-line being made between them. The declination magnetometer and horizontal-force magnetometer record their variations on one horizontal cylinder, and the vertical-force magnetometer on a vertical cylinder, which also receives the trace of the barometer obtained in the following manner:—

The instrument is a large bore one of the syphon form, having the lower surface of the mercury more than one inch in diameter. This surface supports a glass float, from which rises a vertical rod. This rod presses at right angles against a long

and light lever, the greater part of the weight of which and of the float is counterpoised, leaving a small residue only pressing on the mercury. The barometer is about thirty inches from the cylinder, and the fulcrum of the lever is still further off. The lever carries a plate of opaque mica in front of the rotating vertical cylinder, having a small hole in it, through which the photographic light of a gas jet, concentrated by a cylindrical lens, passes, and records the rise and fall of the barometer, which, by the action of the lever, is multiplied four times in length, rendering the indications easily read off. An independent pencil of light, shining through a fixed aperture, traces a base line, from which the heights are measured, a few

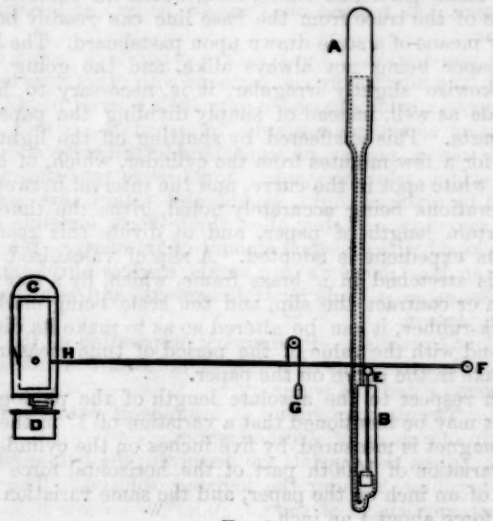


FIG. 2.

eye observations being made every day to obtain fundamental points.

The annexed diagram (Fig. 2) shows this apparatus in detail. A B is the barometer, C the cylinder, D the time-piece, E the vertical rod, F the fulcrum, G the counterpoise, H the lever and mica plate.

Another vertical cylinder, placed under a shed in the grounds of the observatory, photographically records the readings of dry and wet bulb thermometers by a very simple arrangement.

The thermometers are mercurial, and have large bores nearly half an inch in diameter. Fine wires are placed at every degree across a plate which covers the tube, and has a slit in front of the mercury column, with thicker wires at every 10°, and extra ones at 32°, 52°, and 72°.

The light of a jet of naphthalized gas is condensed by a cylindrical lens upon the thermometer tube, and as the mercury rises or falls, it obscures or uncovers the sensitive paper, and leaves a broad photographic trace on each sheet, which shows the height of the thermometer, and the exact degree can be ascertained from the numbers indicated by the spaces of light produced by the intercepting wires. This cylinder is larger than the others, being 13¼ inches long and 19 inches in circumference; it rotates once in 48 hours, and requires no base-line.

The preparation of the sensitive paper is a point of great interest, and after many comparisons with other processes, the following one, which has been very little altered from the commencement of the photographic registration, is still adhered to. It was a matter of considerable difficulty to devise a system which, while the paper should be so sensitive as to be affected by artificial light, should also retain this quality for one or two days, and then allow the hitherto invisible trace to be developed with an equal amount of intensity. We give the process in Mr. Glaisher's own words, slightly abridged:—

"The paper is made by Hollingworth, and is a strong one, of even texture.

"*First Operation.*—Preliminary preparation of the paper.

"1. Sixteen grains of iodide of potassium are dissolved in one ounce of distilled water.

"2. Twenty-four grains of bromide of potassium are dissolved in one ounce of distilled water.

"3. When the crystals are dissolved, the two solutions are mixed together, forming the iodizing solution. The mixture will keep any length of time.

"Immediately before use, it is filtered through filtering paper.

"A quantity of paper, sufficient for the consumption of several weeks, is treated in the following manner, sheet after sheet:—

"The sheet of paper is pinned on a board, and a sufficient quantity (about fifty minims for a sheet of paper fifteen inches long and nine and a-half inches broad) of the iodized solution is applied by pouring it upon the paper in front of a glass rod, which is then moved to and fro till the whole surface is uniformly wetted by the solution.

"The paper thus prepared is allowed to remain in a

horizontal position for a few minutes,, and is then hung up to dry in the air; when dry, it is placed in a drawer till used.

"*Second Operation.*—Rendering the paper sensitive to the action of light.

"A solution of nitrate of silver is prepared by dissolving fifty grains of crystallized nitrate of silver in one ounce of distilled water, adding in hot weather a few drops of acetic acid.

"Then the following operation is performed in a room illuminated by yellow light:—

"The paper is pinned as before upon a board, and (by means of a glass rod as before) its surface is wetted by fifty minims of the solution. It is allowed to remain a short time in a horizontal position, and if any part of the solution remains unabsorbed, the superfluous fluid is taken off by the application of blotting-paper.

The paper, still damp, is immediately placed upon the interior glass cylinder, and is covered by the exterior glass cylinder, and is mounted upon the rotating apparatus to receive the spot of light formed by the mirror which is carried by the magnet.

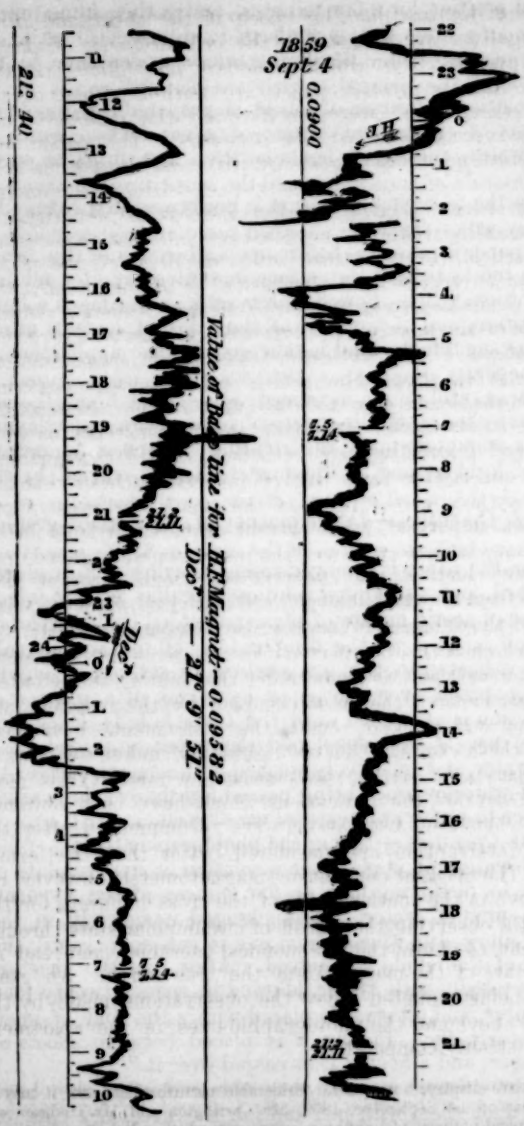
"*Third Operation.*—Development of the photographic trace.

"When the paper is removed from the cylinder it is placed upon a board, and a saturated solution of gallic acid, to which a few drops of acetic nitrate of silver are added (in hot weather this solution is used at the temperature of the air, in cold weather it is heated to the temperature of seventy or eighty degrees), is spread over the paper by means of a glass rod, and this action is continued until the trace is fully developed. When the case is well developed the paper is placed in a vessel of water, and repeatedly washed with several successive supplies of water, a brush being passed lightly over both sides of the paper to remove any crystalline deposit.

"*Fourth Operation.*—Fixing the photographic trace.

"The photograph is placed in a solution of hyposulphite of soda, made by dissolving four or five ounces of the hyposulphite in a pint of water. It is plunged completely in the liquid, and allowed to remain from one to two hours, until the yellow tint of the iodide is removed. After this the sheet is washed repeatedly with water, allowed to remain twenty-four hours in water, and afterwards placed within the fold of linen cloths till nearly dry. Finally, it is placed between sheets of blotting-paper, and a heated iron passed over it."

From the original records thus obtained, after they have had placed upon them with pen and ink the necessary data of the times of the breaks in the curve to obtain the time scale,



FAC-SIMILE OF PHOTOGRAPHIC TRACE OF 4TH SEPTEMBER, 1859.

the value of the base line, the epoch of the sheet, and other data, negatives are prepared in the ordinary way of photographic printing, from which secondary photograms positive tertiaries can be printed, which are faithful copies of the original sheets that were placed round the cylinders, and such copies are distributed when necessary. The paper used for the printing process is made by Rive, and the salting solution is chloride of ammonium, and the sensitizing one ammonia-nitrate of silver. Having by the kindness of Mr. Airy, the Astronomer Royal (who has supplied every information necessary for this article), been furnished with a duplicate of one of the photographic records, and permission to use it in any way thought desirable, we are enabled to offer our readers a reduced *fac-simile* of the trace on the horizontal cylinder which records the variations of the declination and bifilar magnetometers. The date is 4th September, 1859,* and the wood engraving, although unable to give the full effect of the photographic curve as to its minute inflections and transparency, is most curious and interesting, and, we believe, the first opportunity most of our readers have had of inspecting these beautiful tracings by the pencil of light, of the occult workings of one of the most important, and at present obscure, physical forces.

We have hitherto spoken of the instruments as placed upon the ground level of the observatory, which position they occupied from its establishment until last year, when in consequence of the difficulty of keeping the temperature nearly constant (and unless this be effected the variations are influenced by it) an excavation was made under the building to the extent of the three arms of the cross occupied by the magnets, and this being well bricked round, the instruments have been placed in these vaults, which are lighted by sunken windows of yellow glass; and as the temperature now rarely varies more than 10° from 60°, the indications which have been obtained this year when the observations were recommenced after the necessary interruption, are considered better than the former results. The original declination magnetometer, however, remains above in the southern arm of the cross building, for the sake of still observing the transit of circumpolar stars through the roof-slit, to obtain the astronomical meridian, and read off the departure of the magnet from the true north. An exact duplicate being mounted below the observations made by the theodolite above and the photographic ones in the apartment below are strictly comparable.

* The curve displays some very considerable perturbations, and it may be remarked that on 1st September, 1859, Mr. Carrington and Mr. Hodgson witnessed the violent outburst of light on a solar spot, which affected magnetic instruments simultaneously in all parts of the globe.

The saving of labour resulting from the introduction of the automatic registration of the instruments is most considerable, involving the release of two assistants at least, and an entire absence of night work. The observations are also more exact, and being continuous instead of intermitting, is, in the case of instruments whose changes are so incessant and capricious in their nature, an advantage that cannot be estimated too highly.

The system thus inaugurated at Greenwich has been adopted at the observatory of the British Association at Kew, and will no doubt be used in the cases where instruments are supplied from that establishment; and at Oxford the meteorological observations are registered in a similar manner.

It only remains to mention that, during the last few months, an interesting addition has been made to the photographic recording apparatus at Greenwich. In order to detect electrical currents in the earth, two wires are stretched, the one to Dartford and the other to Croydon, passing into the earth at both ends, and having galvanometers included in the circuits; but no batteries are employed. Each magnet has a mirror mounted, by which a spot of light is reflected to a photographic sheet, mounted on a cylinder made of ebonite, and the curves are thus registered as in the other cases. The apparatus has only been mounted about two months, and it is too soon to infer anything from the results; but it may be mentioned that the Dartford current, running E. and W., is stronger than the Croydon, which runs from N. to S.; that both are stronger than was expected; and that the trace of the Dartford current occasionally bears a strong resemblance to that of the declination magnetometer. Such indications cannot fail, when observed sufficiently long and properly discussed, to throw light upon the causes of terrestrial magnetism, and add another to the benefits resulting from the operations of Greenwich Observatory.

LUNAR DETAILS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

In our last paper we did not quite terminate the subject of *Proclus* (12). This crater is the origin of several luminous streaks, which, however, are well seen only under favourable circumstances. Two take the direction of the *Mare Crisium*, and may be traced as far as its centre. Schröter, on one occasion, 24h. after Full, when the W. edge of the plain lay on the terminator, perceived three crossing nearly its whole extent. This grey level should be watched with reference to variations of this kind. From more than one source I have been favoured with observations proving that something similar to the appearances described in Int. Obs., v. 203, may occasionally be perceived.* A collection of radiating streaks also issues from *Proclus* towards the N.E. In this direction a very sharp and nearly straight line connects *Proclus* with a small crater, *Proclus d*. This line marks the course of a slight declivity, at the foot of which lies the—

Palus Somnii, a remarkably well-bounded and always distinguishable region, E. of *Proclus*, having a form somewhat resembling an irregular rhombus, or heraldic "lozenge." B. and M. observe that its colour is quite peculiar, but difficult to be designated; something of a yellowish brown. It is altogether occupied by hills of no great elevation, chiefly following a meridian direction; and its aspect is singular, unlike that of the other regions which Riccioli comprises under the general term *Paludes*, but probably much resembling many regions of our own globe. The region S. of *Proclus* is of a somewhat similar character: the shortness of the shadows here thrown towards the *Mare Tranquillitatis* (D) and the *M. Fœcunditatis* (P), as compared with those falling in the direction of the *M. Crisium* (A), indicate the considerably deeper level of the latter surface.

The *Mare Tranquillitatis* (D) gives rise to a remark by B. and M., that from a merely superficial glance at the lunar disc, it might appear as though its seas were diverse only in form and magnitude; but a more careful comparison under various incidences of light will bring out so many peculiarities in each of them, as alone to prove, even if no other grounds for the contrary belief existed, the insufficiency of the assumption of a general covering with water or any other homogeneous fluid. This extensive plain is divided from the *M. Serenitatis* on the N.E. in a singular way, by a very straight and continuous slope of

* See Mr. Slack's observation, Int. Obs. vii. 322.

trifling breadth, but, according to Schröter, more than ninety miles in length, proving that the latter plain, in this region at least, must lie at a lower level: its remaining boundaries are more distinctly made out by its hue than by any strong, natural configuration of mountain or cliff. Its colour is a clear grey, without any trace of green or other distinguishable hue. The surface is diversified and "marbled" by a multitude of very minute streaks of light, perceptible only under the most favourable circumstances. It is intersected by a number of long, low banks, many of which unite themselves in a broad central mass of slight elevation. To this plain belongs the conspicuous crater *Plinius* (13), a cavity thirty-two* miles in diameter, with an interior full of small inequalities, a ring built up in terraces, and a luminous central hill; the whole forming a very confused, though brilliant mass in the Full Moon. The wall, which is much blocked up by its exterior adjuncts, is, according to Schröter, more than nine miles broad, nearly 1400 feet above the neighbouring region, and 7300 feet above the interior (1000 feet more than is given by B. and M.). On two occasions, with two different instruments, and with an interval of more than twenty-five years, I have seen the two summits of the central hill figured by B. and M. as minute craters. Such illusions may easily take place when the shadows of small eminences fall among other elevations of a similar character, and show the necessity of caution in forming conclusions under these circumstances. *Plinius* A, a crater of fourteen miles in diameter, just to the W. of *Plinius*, is remarkable as the centre of a large white area, considerably brighter than the surrounding level. Its W. side has 8° of brightness, the E. wall is 2200 feet above the outer plain, and the depth, according to Schröter, is at least 5700 feet.

S. of *Plinius*, in the region between it and the equator, lie three pairs of craters near the E. edge of the plain:—*Ross*, 4100 feet deep according to Schröter, and *Ross* A—*Arago* and the much smaller *Arago* A—and *Ritter* and *Sabine*: the four first remarkable, as well as other craters in the district, for the corresponding position in each case of a "wall-peak" or tower on the S. edge of the ring; the two last as forming a double ring of which the components are nearly similar. The W. wall of *Ritter* (the more easterly and higher of the two) is 4000 feet above the interior. Nearly W. of this last pair,

* Schröter gives twenty-five miles; L. thirty-five. The discrepancy may in this case probably be ascribed to the circumstance that the ring is of an oval form. But, generally speaking, those who are accustomed to lunar observations will feel no great surprise at variations of this kind, which may naturally occur when the wall is of a terraced construction, without any very dominant crest, and the shadow may consequently be cast from different ridges under different angles of illumination.

across a wide extent of grey level, lies *Maskelyne* (14), a crater about 18 miles across, 4500 feet deep from the E. side of its irregular ring, and 3000 from the outer level. L. assigns to it a central hill, neither figured nor described by B. and M. Less than half way from this crater to *Taruntius* (91), we find a considerable grey ring in the plain, and a little N. of it another somewhat smaller, whose E. sides, about 300 feet high, are lost to sight 16h. after the terminator has past them, so that the opposite portions alone remain visible, like isolated curved hills, as in fact they are figured by L.—B. and M. observe that "many lunations may pass without even the most attentive observer's perceiving anything of them; this evening they are *not yet*, to-morrow morning they are, perhaps, *no longer* to be seen." The preceding details have been introduced for the sake of this valuable remark, whose application is of a more extended nature.

Mount Hæmus.—By this name, introduced by themselves, our authorities designate the S. boundary of the *M. Serenitatis* (E), from the neighbourhood of *Plinius* (13), to *Menelaus* (15), and about as much further again, to a small luminous crater, *Sulpicius Gallus*. No region, they observe, excepting that adjoining *Vitruvius*, exhibits within so small an area so many contrasts of "light-tone," visible even on the dark side of the moon, and producing a charming effect in the eclipse of December 26, 1833, when even the minutest objects were perfectly distinguishable. Some parts of the range attain 8° or 9° of reflective power in the Full Moon, and a multitude of bright specks lie scattered about the vicinity. In proceeding eastward from *Plinius*, we pass a beautiful chain of "islands," the highest not attaining 800 feet, before reaching the *Promontorium Acherusia*.* The headland so called rises to 4800 feet, with an aspect which may, as B. and M. remark, resemble "Cornwallis and Alaksa" (Cornwall and Alaska?), seen from the moon. The mountains rise and spread, forming the coasts of two different *seas*, the *M. Tranquillitatis* and *Serenitatis*. Following the shore of the latter, we soon reach—

Menelaus (15), a fine crater; according to Schr. 16m. broad: L. makes it 21m. B. and M. have given no measure. They describe it as having a broad ring, the interior of which reflects the light at different times from one or the other side, almost like a concave mirror, whence its great brightness of 8° and 9°. Its steepness conveys at first the impression of a greater depth than it possesses; it is actually, however, very con-

* Spelt *Archerusia* by Hevel and Schr., and in the great map. The text, however, seems to be right. It is the ancient name of a headland in Bithynia, near *Byzantium*, the appellation given by Hevel to the crater now called *Menelaus*.

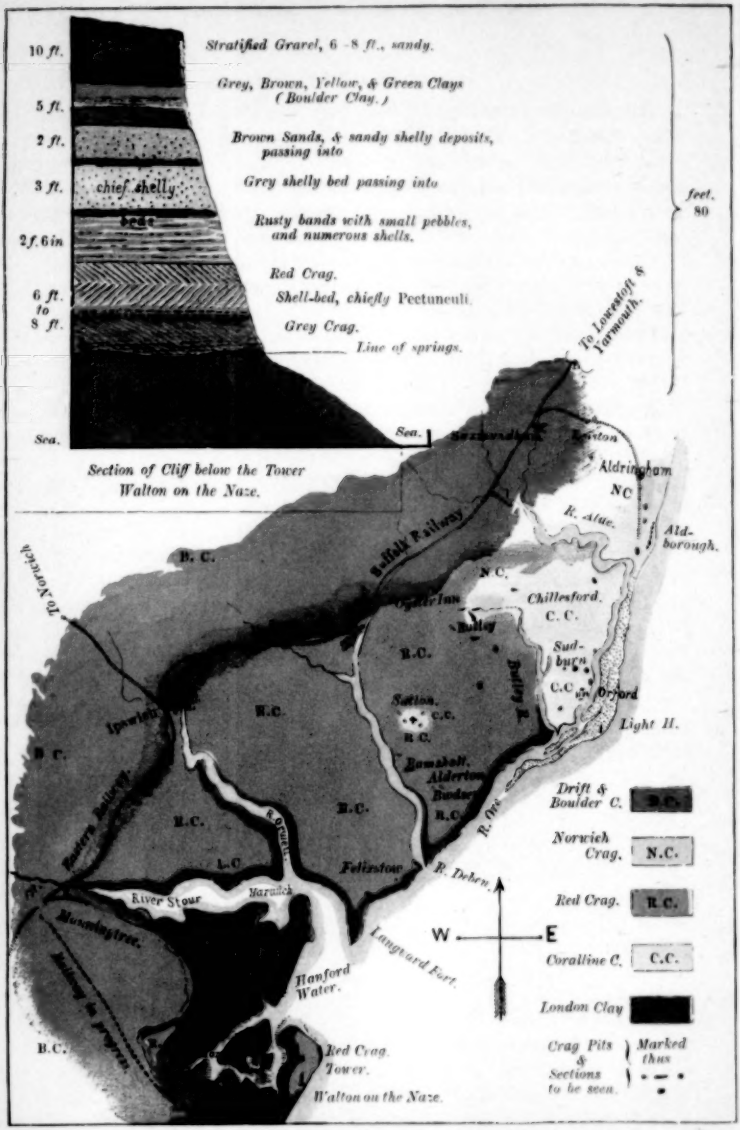
siderable. B. and M. measured it at about 6600 feet; and 5500 feet under a doubled angle of illumination, when the end of the shadow would fall in a less depressed part. Schr.'s two measures gave about 8000 and 7500 feet. The smaller crater, *Menelaus b*, lying just S.W. of the larger one, has, according to Schr., a depth of 4570 feet—greater in proportion to its diameter, as he always observed with regard to the lesser cavities.

From one of the "Phases" (No. 9) of Hevel's ancient *Selenographia*, it would appear that some mountains in this vicinity must be of extraordinary height. He makes their projection into the night side, even in a necessarily somewhat foreshortened position, with a W. long. of 16°, $= \frac{1}{10}$ of the moon's diameter, or as great, at least, as that of any lunar elevation. Schr. is mistaken in ascribing this supposed height to the W. end of the *Prom. Archerusia*, as it is evident, both from Hevel's figure and description, that he refers it to the other end of the promontory, in the immediate neighbourhood of *Menelaus*. The assertion is not borne out, and seems not to have been thought worthy of remark, by later selenographers; yet Hevel was so careful in his way that it might be as well to examine whether any shaded depression, where the terminator crosses the *M. Serenitatis*, may cause an illusory effect of projection.

B. and M. here call attention to a very curious fact, that all the mountain ridges proceeding from *Menelaus* run in a S.W. direction, and that this parallelism extends not only through all these high lands, but prevails also almost exclusively through the greater part of the *Apennines* (23), and all the mountainous regions lying to the S., as far as the craters *Pallas* and *Bode* (28), and to the other side of the equator, flattening even the circular forms of the craters in its way. They further observe that since what we call W. on the moon (*i.e.* turned to our W.) would appear E. to an eye transported there (an apparent reversal of bearing taking place in looking at the moon, just as when we stand face to face with another person, whose right hand is opposite our left), therefore this S.W. direction of lunar parallelism corresponds in reality with that from S.E. to N.W. so prevalent on the terrestrial globe.

Menelaus is the starting point of several luminous streaks, which for the most part belong to the *M. Serenitatis*, except one which runs to the S.E. Occasionally, B. and M. say, this streak, a strong one in the *M. Serenitatis*, and some others lying N. and S. in the same direction, appear to be only portions of one great ray reaching from *Tycho* to *Thales*, through upwards of 1800 miles. This is more evident with low powers, which, however, are apt to give apparent unity where higher ones show distinction.

The E. portion of *M. Hæmus*, which runs off into the *M. Vaporum*, attains a less elevation than the other end, and can scarcely be termed mountainous. In concluding their description of this region, B. and M. remark the striking and unmistakeable contrasts of reflective power that are here crowded into a small space, and are many of them independent of the relief of the surface. In general the mountains are bright, and the valleys dark. Yet, under an oblique illumination, it is obvious how slight or imperceptible a difference of level is frequently combined with great inequality of light, while in other far more uneven regions, such as those lying N. of the *M. Serenitatis*, and the *Carpathian Mts.*, not to mention the S.W. Quadrant, an uniform degree of brightness prevails. Is this, they inquire, to be ascribed to some peculiar cause in the original formation of the moon, or to some persistent reason? This district seems to them highly worthy of a more careful and less fragmentary investigation than it has yet received; they content themselves, however, with remarking that they have repeatedly thought that the separate portions of the surface nowhere show a clear and decided "light-tone," but rather an almost inextricable mixture, as though from a mechanical union of specks of light and darkness. It does not seem very likely that a larger instrument than that used by B. and M. (which had barely 4½ inches of aperture) would be of any great service in unravelling these mysteries, since the superfluous amount of light in the brighter portions would produce a dazzling, rather than a discriminating effect. But with the addition of a lightly-tinted screen-glass, great apertures might prove very efficient; though an objection may possibly lie against the employment of a coloured medium in very delicate observations, from the partial absorption it must exercise on light, the composition of which is uncertain: in this point of view an interesting experiment might be tried, by the successive introduction of a number of differently tinted screens of equal depth, the result of which might possibly be the detection of colours in the moon, too delicate to be otherwise recognized. But—excepting for such an investigation—it is probable that the employment of an unsilvered glass speculum might produce the most satisfactory result. On this subject the reader may be referred to Dr. Draper's experience, recorded in our last number; and there seems reason to believe that an instrument of this kind, ensuring the defining power which is the result of large apertures, without either an overpowering glare of light, or any objectionable mode of lessening it, might be found of especial value in lunar observation.



Map of the CRAG DISTRICT.

COLOURS OF STARS.

In the last number of the INTELLECTUAL OBSERVER were some remarks on the desirableness of noting on an extensive scale the existing colours of stars, in the hope of obtaining more extensive and decisive evidence as to their presumed variability. The following instance will tend to show that a little attention bestowed in this direction might be well repaid.

1865. June 22. Happening to be looking at the beautiful group, σ^3 Cygni (No. 58 of our list), without at the time knowing the object, I noted the colours (the letters indicating the magnitudes), A orange yellow, C sapphire blue, B white, or very pale yellow, with a sort of cast of blue in it, but certainly not at all like C. The latter star I found kept its colour when A was out of the field. I subsequently found what I had been looking at, and that each of the smaller stars had been recorded by Struve "cœrulea," 1835·95, and by Sm. "cerulean blue," 1838·67, with the addition that at Dorpat the two smaller stars preserved their blue colour when the larger star was hidden. On the contrary, I found that in an old observation of my own, 1850·77, with $3\frac{7}{10}$ inches of aperture, I made B white, C blue; there being no difference among the observers as to the colour of A. I have subsequently received from more than one quarter a full confirmation of my belief that the two stars are now no longer of the same colour; and the change, as it appears, must have taken place in the period intervening between 1838 and 1850. Without laying too much stress upon this case, we may at least admit that it furnishes an appropriate stimulus to further inquiry.

AN EXCURSION TO THE CRAG DISTRICT.

BY HENRY WOODWARD, F.G.S., F.Z.S.,
OF THE BRITISH MUSEUM.

(*With a Coloured Map.*)

THERE are numerous localities in our island but seldom explored, where the holiday-maker and amateur geologist may collect for himself, and in so doing learn far more about rocks and fossils than he can ever do from books alone. With this view I propose to give some account of an excursion made along a portion of the eastern coast, in company with my friend Mr. Bakewell, for the purpose of seeing the Suffolk Crag, and collecting Crag-shells.

We started by the "Metis" steamboat from London Bridge Wharf, at 10 a.m., to "Walton le Soken," alias "Walton on the Naze," a quiet little out-of-the-way sea-side village in Essex, at which we arrived at two o'clock p.m.

The run by the "Metis" and "Father Thames" steamers between London and Ipswich, passing down the Thames and up the river Orwell, forms a short and most delightful summer's-day voyage, and those who can resist the *maladie du mer* will be well repaid by the pretty rural scenery of the Orwell at high tide, which on either bank is wooded, often to the water's edge. The sea trip must be enjoyed for the sea itself, as nothing will be visible of the land between Shoebury-ness and Walton, for you will notice by the map that the low flat coast of Essex retires up towards Colchester, leaving a large area of shallow water outside, which the steamboats keep, and the land being very low, is nearly, if not wholly out of sight.

The aspect of the Essex coast, composed of denuded Secondary and Tertiary strata,* contrasts very strongly with the corresponding western shore, where the oldest rocks of our island make up, by their vast thickness and repeated crumplings, the ancient Welsh mountains, snow-capped for more than half the year.

If unvisited by the summer steamboats, Walton would be nearly as isolated from the rest of the world as the Channel Islands. The "Naze," or neck of land on which the village stands (see Map) has the sea on the east, north, and west, and is approached from the south only by a single road. It is eighteen miles from Colchester,† and although within seven miles of Harwich in a direct line, it is fourteen or fifteen by the nearest foot-ways round the salt marshes.

A little to the north and south of the village the cliffs rise from forty to eighty feet for a short distance, sloping down inland to the salt marshes in the rear. It is that portion of the cliff about a mile to the north of the village where the nearest Crag "out-crop"‡ occurs. The spot is well marked by a lofty hexagonal tower, eighty feet high (erected by the Trinity House Board as a landmark and signal-tower for ships). The tower itself stands in the middle of a field between the road leading to Walton Hall and the cliff. Just below this, in the face of the cliff, the Crag may be seen (see Section). It is easily distinguished from the London clay by

* Chalk and London clay, with patches of Crag and Boulder-clay.

† A branch railway is about to be opened to the little town.

‡ The section given in the coloured plate is taken at this spot, and the measurements and details have been kindly furnished me by my friend, Robert Etheridge, Esq., F.R.S.E., F.G.S., etc., Palæontologist to the Geological Survey.

the deep red stain, due to oxide of iron, which has caused this division of the newer Tertiary to be called "The Red Crag." It overlies the London clay, which here contains traces of decomposed vegetable remains and abundance of gypsum (*selenite*) in clear crystals, but no shells or animal remains.

The village stands upon the lowest part of the Naze, and the land rises both to the north and the south.

The sea constantly encroaches here and has much reduced this little peninsula. There is a breakwater to the north of the pier made of stone, about 500 yards long, on which a terrace is built, and the Coastguard Station-house. Beyond this the only protection afforded to the cliff is by rows of piles driven in pairs into the beach in straight lines, with planks of wood placed between them. These are being rapidly destroyed near low water by the *Teredo*, and may be crushed beneath the foot.

Great masses of the blue London clay, which here forms a large proportion of the cliffs, fall from time to time with a heavy thud upon the beach, causing the passer-by to start aside and congratulate himself on his escape.

At one part of our walk along the footpath on the top of the cliff we came to the corner of an enclosure which abuts so nearly upon the edge of the precipice, that the stile (three feet wide) only remained between it and the fence. Probably by this time the footpath itself is gone.

The great agents at work in assisting the sea to undermine these cliffs are the land-springs, frosts, and thaws. Springs occur here every few yards, and where a spring is, there the cliff is most unstable.

At the point where the Crag is seen, an attempt has been made to save the cliff by cutting deep trenches, or gullies, and placing drain pipes and faggots in them to guide the water direct to the beach. A considerable quantity of Crag has thus been thrown out, and where not overgrown with weeds and grass, we found the surface covered with Crag-shells washed out by the rain; many hundreds were broken, but some still remained perfect.

I may here state that the Crag is composed almost entirely of shell-remains, interstratified with bands of sand and gravel (see Section), and containing, especially in the Coralline Crag, undisturbed reefs of Bryozoa and shell-banks, buried, and afterwards upheaved, just as they had been formed in the sea.

The Crag being very friable, it is far easier to discover perfect shells than to extract them from the loose matrix. Even when this has been accomplished, the greatest care is

needed in packing them, or you will find only shell-gravel in your box on returning home.*

We were able, on our first visit, to ascertain the best place to work the Crag, and had also procured some six or eight genera of shells, as proofs of the existence of the formation; but as it was now too dark to collect, we determined to return to the inn, where we unpacked our Crag and made a few notes thereon.

Among the characteristic fossils of the Red Crag we found the following shells:—*Fusus contrarius, F. costatus, Murex alveolatus, Buccinum Dalei, Nassa reticosa, Voluta Lamberti, Pectunculus glycimeris, Lucina borealis, Cardium Parkinsoni, C. angustatum, Mactra arcuata, Artemis lentiformis,* and a tiny sea-urchin, *Echinocyamus Suffolciensis.*

Certain of these are very abundant, and others only rarely met with entire; thus *Fusus contrarius* and *Pectunculus glycimeris,* are exceedingly common, whilst *Voluta Lamberti* and *Cardium Parkinsoni* are extremely rare, and would be highly valuable finds.

Early on the following morning we again set out for the Crag, after having first purchased a small spade. We worked away at the undisturbed Crag with our spade and long knives all day, returning to a late dinner at the inn.

Our collection was not large, but we obtained some very fair and perfect specimens, and as we hoped to do more at Sutton and Sudbourn, we decided upon marching on the morrow to Harwich.

We were up by five next morning, and after having breakfasted, mounted our knapsacks and started for Harwich. Having ascertained that we could cross Hanford Water from Stone Point to the Harwich side of the salt marshes, and so save six miles, we decided to endeavour to catch the Revenue-cutter's boat at high water, the only time a landing can be effected.

We were just in time to save the tide, and were soon crossing towards "Peewit Island." We found it a good mile across from Stone Point to the landing at the head of the creek leading to the sea-wall, along which the footpath runs. The tide was running out at a great rate, and made rowing up the narrow stream a very difficult operation. Having each taken an oar, we pushed until we were fairly aground, and then we saw, about three boat's-lengths off, the first stepping-stones leading to the longed-for footpath. This was most tormenting, as the mud was up to our waists. At length the ingenuity of

* Most of the Crag-shells, especially the bivalves, require to be strengthened by the application of repeated coatings of thin gum-water, which is absorbed readily and hardens the tissue of the shell.

our boatman got us over this dilemma. In the bottom of the "punt" he had three strips of board, and by placing these cautiously one beyond the other, and supporting each of us with an oar, he passed us one by one along this narrow gangway to *terra firma*, and so, after a muddy walk on stepping-stones, we reached the sea-wall *en route* for Harwich. There formerly existed a cliff capped with Crag here, but it has been long since washed away.* Harwich and Dovercourt cliffs are now both well protected against further encroachments of the sea by an excellent stone breakwater, two miles in length, which affords a fine walk to visitors, who come yearly in increasing numbers to enjoy this rising Spa.

We came into Harwich with good appetites, after satisfying which we crossed the Orwell in a sailing boat, and landed at Walton Ferry, intending to push on, through Felixstow and Alderton, to Ramsholt that same night if possible. We walked over some fields which terminate the county of Suffolk, upon the extreme southern point of which Landguard Fort is situated, and came once more upon the beach a mile south of Felixstow. Here the cliffs again rise up to a good height, with Crag and London clay, but we did not succeed in procuring any fossils.

At Felixstow I found a letter from my friend, Mr. Colchester, of Grundisburgh Hall, one of the largest exporters of coprolite from this county, inviting us to inspect the Crag pits on his estate at Sutton, of which we had heard such interesting accounts from Mr. Searles Wood. We were constantly reminded of our proximity to the Crag by observing the private roads gravelled with it, and we picked up several entire shells of *Litorina* and *Murex* as we walked along.

Near Bawdsey Ferry we noticed in front of the cottage-doors small heaps of the dark-brown, shining, water-worn pebbles called "coprolites," which ten years ago created an extensive trade here, and the preparation of which for artificial manure gave employment to numbers of peasantry.

The superior yield† of the coprolitic deposits of the Cambridgeshire Greensand, which give a more abundant supply

* The men employed by the Harbour Commissioners in "didling," or dredging up stones, etc., in the entrance to the Orwell and Stour rivers, off Harwich, collect vast numbers of *Septaria* (huge concretions washed out of the London clay, which are used in the manufacture of "Roman cement"), nearly every one of which contains some organic body in its centre, around which the mass seems to have formed. Those found at Harwich frequently contain the remains of fossil turtles.

† Mr. Colchester informs me that himself and another proprietor at Royston raise no less than 300 tons of this fossil manure *daily*, or about 93,300 tons per annum.

of "superphosphate," has tempted Mr. Colchester to a new and more attractive spot at Royston. The nodules of this coprolitic deposit of the Crag contain numerous organic remains, some of which, such as the crustacea, teeth of fishes, etc., appear to have been derived from the *débris* of the London clay, and some few from still earlier formations; but the larger proportion, including the mammalian teeth and bones, most probably represent the wreck of the Miocene or Middle Tertiary series, so well developed in France and Germany, but (with the exception of the Bovey-Tracey lignite and the Hempstead beds in the Isle of Wight) almost unknown on this side of the Channel. They are certainly the oldest part of the Crag formation.

We were rowed across the Deben in a small boat, and, leaving the river, walked up the hill through the village of Bawdsey to Alderton. We should have done wisely had we halted here for the night; but as Mr. Searles Wood had told us that Ramsholt Dock Inn was the place he staid at some years before when working at the Crag, we determined to put up there, as it was only two and a half miles beyond Alderton. My friend and I tried it for one night, and our advice to collectors intending to go there at night as we did is—*Don't!*

Early next morning we started out again, and five minutes' walk brought us to the river-side and the Crag, and we were soon at work poking away at the bright red-stained Crag-bank. This is the hardest Red Crag I have seen; the percentage of iron is much greater, causing it to cake firmly together, and resist disintegration. The strata are very curiously false-bedded, and there is a good illustration of unconformability between the upper and lower beds. We procured here very fine specimens of *Fusus antiquus*, *Natica millepunctata*, and *Trochus ziziphinus*.

Passing up the river side, we came to a small plantation, in which is a Crag-pit, with a bed of *Modiolæ in situ*; but the valves lie so close together, and are so brittle, that it is almost impossible to obtain an entire specimen.

Leaving the river, we ascended the hill towards Mr. Colchester's farm at Sutton. We saw the first large accumulation of "Coprolite" here, lying at the entrance to a field, probably twenty tons; we picked up a water-worn tooth of the great shark *Carcharodon*, and another of *Lamna*, but no good examples of coprolites, although some pieces showed the twisted form slightly.

On inquiring for Mr. Wood (Mr. Colchester's steward), he soon appeared, and was most obliging and attentive to us throughout. He amused us by pulling from his pocket a

handful of sharks' teeth, two fossil crabs, and a very fine corkscrew coprolite, the best specimen I ever remember to have seen. These he presented to us.

The first pit we worked at was in the Red Crag. Here we obtained many perfect shells of *Natica*, *Pecten*, *Pectunculus*, *Fusus*, etc. Then to a Coralline Crag-pit, where we were told Mr. Searles Wood obtained his *small* shells.

Our guide proposed to send us up a sack of this per rail, to pick over at home at our leisure. I am sorry I declined the offer, as I don't doubt but it would well repay the trouble of sifting. The minute forms of Bryozoa,* of which it seems almost entirely composed, were very beautiful, and we picked out a good number, also many small shells of *Cerithum*, *Turritella*, and *Scalaria*, *Fissurella* and *Calyptræa*.

At a larger pit, further on, also in the Coralline Crag, we obtained innumerable *Pectens*, and specimens of *Cardita senilis* and *scalaris*, *Astarte sulcata*, *gracilis*, and *Omalii*, *Cyprina rustica* and *Islandica*, the latter in a regular bed around the pit, and higher up a band of *Terebratula grandis*, of which we procured several fine detached valves, and two small entire pairs, also a very good specimen of a sea-urchin (*Temnechinus*), and many other additions to our scrip.

The Crag is often very much disturbed, and in one pit we visited we saw the Red and Coralline Crag mixed together in most charming confusion.

Our load of specimens now became formidable, and the prospect of a heavy march caused us to hurry away from this grand locality rather faster than either of us desired; but we had planned to reach Orford that night, if possible; so we contented ourselves with securing our present acquisitions safely.

Our obliging guide now volunteered to drive us half way to Orford, and we gladly accepted his offer. We rode across Sutton Heath and Hollesley Common, between plantations and down green lanes, till we pulled up at a neat road-side inn, "The Butley Oyster," where we halted, dismissed our cozy little vehicle and white horse, and after a hasty meat-tea, resumed our knapsacks and crag-shells.

Had it been early day, instead of twilight dim, we should have been tempted to halt and turn aside to look at many a likely pit marked on our Ordnance map; but we had five miles of turnpike before us, and a heavy lot of fossils to carry by turns, and our knapsacks likewise; the road, however, was good, and the evening clear.

After leaving the village of Chillesford (where the Norwich

* See Mr. Busk's interesting monograph on the crag Polyzoa, *Pal. Trans.* 1859.

Crag occurs) we came to Sudbourn Park gate, but not being quite sure of the way through the park, we kept to the turnpike, and soon hailed the Orford lights.

Every village in Suffolk, of any importance, has its "King's Head" and "Crown" inns; we went to the former, and after a night at the "Ramsholt Dock Inn," were both prepared most thoroughly to appreciate this comfortable little place.

Having ordered supper, we sallied forth to inquire for a celebrated character at the "White Hart," known as "Jumbo" (*alias* William Brown). This oddity is a thin, wiry old man, between sixty and seventy years of age, and the most handy fellow in the parish. He is* the living oracle here on Crag-pits and shells, and must be invoked and propitiated with beer and shillings if you want to find the best of both. He is, however, troubled with fits of "brooding melancholy" (the effects of over-potations), when he will not respond to any call, and must be dispensed with. Such was his mood at this time.

His knowledge of Crag-shells places hi in a very exalted position, and among the rustics he is considered quite a distinguished palæontologist. Having obtained this information, we returned to our inn, and after supper cleaned and packed our day's collection of Crag.

We were up early next morning, and examined the old Norman arches of the chancel of the original parish church, but found no ferns thereon. Then we visited the Castle, a once famous Norman stronghold, and covering a large area of ground, as may be traced by the green hillocks and remains of ancient stonework here and there protruding through the soil. The view from the summit over Orford Ness to seaward, and inland across Sudbourn park and woods, and down upon the little town beneath, is very picturesque. We gathered a plant of wall-rue, or rue-leaved spleenwort (*Asplenium ruta-muraria*), from the wall of the Oratory (it is still living in my friend's fernery as a memento of our visit). The upper part of this fine old edifice is rapidly falling to decay from neglect.

Orford is an example of a maritime port and fishery from which the sea has been shut out by the formation of an extensive bank of shingle ten miles long, which is only divided from the mainland by the river Alde. This river, which formerly entered the sea five miles north of

* "He is," we ought rather to say "*he was*," for "Jumbo," like the crag itself, is now a thing of the past. Stimulated by a sovereign given him by my friend Professor Suess, of Vienna, "Jumbo" took an overdose of brandy, and, alas! went to the spirit land.

Orford, is now turned south, and runs between the old beach and the new bank for ten miles before it finds an outlet to the sea.* (See Map.)

At other parts of the coast, as at Dulwich, the sea is gaining on the land, and this alternate encroachment and retiring may be seen slowly going on at intervals along the whole eastern and south-eastern coast, and serves to explain by analogy many of the changes in coast-lines which have taken place far back in past ages, the record of which was not kept by man.

As we could not get "Jumbo," we persuaded the landlord to accompany us to the pit in the park where the same great beds of *Cyprina Islandica* and *Terebratula grandis*, which we had observed at Sutton the day before, were again visible. All the best shells were however too brittle (owing to the wet state of the soil) to be obtained entire, so that we got very few rarities.

After dinner "Jumbo" presented himself, and said he had some Crag-shells for sale. We condescended to receive his overtures, and bought 10*s*. worth of him, which made up a pretty complete series, and the whole afternoon was occupied in packing them for London.

The weather had now taken such an unfavourable turn that we decided to forego the examination of the Mammaliferous Crag at Chillesford, and many other Red and Coralline Crag-pits around Orford, where good specimens can be obtained, or interesting sections of the Crag seen.

Although Aldborough may be preferred as offering superior marine attractions to Orford, I am persuaded the latter place affords the best "Head-quarters" to any one who desires to have a pleasant holiday in the country, and collect Crag fossils at the same time.†

* The beach at Felixstow is travelling south in like manner, seriously impeding the navigation at the mouth of the Orwell, near Harwich, and creating the greatest anxiety for the port of Ipswich.

† For figures and descriptions of the Crag fossils, see Mr. S. V. Wood's *Monograph on the Shells*, 2 vols. 1848-56; Mr. Busk's *Monograph on the Polyzoa*, 1859; Mr. Darwin on the *Cirripedia*, 1851, in the *Transactions* of the Palæontographical Society.

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

BY G. M. WHIPPLE.

1865.	Reduced to mean of day.					Temperature of Air.			At 9·30 A.M., 2.30 P.M., and 5 P.M., respectively.		Rain—read at 10 A.M.
Day of Month.	Barometer, corrected to Temp. 32°.*	Temperature of Air.	Calculated.			Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	Proportion of Sky clouded.	Direction of Wind.	
			Dew Point.	Tension of Vapour.	Relative Humidity.						
	inches.	°	°	inch.		°	°	°	0—10		inches.
April 1	30·059	45·0	36·3	·314	·74	53·3	44·4	8·9	9, 6, 5	NW by N, NW, NW by N.	0·048
„ 2	...	...	...	...	...	54·5	31·5	23·0	...	... ...	·006
„ 3	29·871	44·9	35·7	·313	·72	53·8	41·1	12·7	1, 7, 8	SE by E, E, E.	·000
„ 4	30·205	46·2	35·3	·328	·68	57·5	37·1	20·4	10, 3, 3	—, WSW, WSW.	·000
„ 5	30·267	47·8	47·5	·347	·98	55·0	40·8	14·2	10, 10, 10	SW, SW, SW.	·004
„ 6	30·261	51·6	45·1	·394	·80	60·1	46·1	14·0	3, 7, 7	SW, SW, SW by W.	·057
„ 7	30·185	52·0	48·1	·400	·88	60·0	45·6	14·4	8, 10, 10	SW, SW by S, SW.	·000
„ 8	30·101	54·7	46·4	·438	·75	67·8	40·2	27·6	6, 2, 0	—, —, SSE.	·000
„ 9	...	...	...	...	...	72·3	38·8	33·5	...	... ...	·000
„ 10	30·241	59·6	44·5	·516	·60	69·4	40·7	28·7	0, 0, 0	NW by W, NNW, NNW.	·000
„ 11	30·206	56·3	42·8	·462	·63	67·6	39·9	27·7	0, 2, 0	SE by S, —, E.	·000
„ 12	30·032	52·3	34·8	·404	·54	62·0	41·4	20·6	8, 7, 8	E, E by S, E by N.	·000
„ 13	29·946	54·2	45·4	·430	·74	64·0	43·5	20·5	2, 7, 8	SSW, SW, SW.	·000
„ 14	...	...	...	...	...	56·3	44·7	11·6	...	... ...	·000
„ 15	30·137	44·1	42·8	·305	·96	53·1	44·1	9·0	10, 10, —	ENE, —, NE by N.	·130
„ 16	...	...	...	...	...	65·4	41·2	24·2	...	... ...	·002
„ 17	29·916	59·9	52·1	·521	·77	68·3	49·7	18·6	10, 10, 10	ESE, SSE, S by W.	·162
„ 18	29·910	56·2	52·9	·460	·89	65·1	51·8	13·3	9, 10, 10	S by W, W, S.	·025
„ 19	30·141	51·4	49·7	·391	·94	60·8	48·0	12·8	10, 10, 9	NE, N, N by W.	·015
„ 20	30·169	52·9	46·9	·412	·81	64·1	44·2	19·9	10, 0, 0	NE by E, NE by E, NNE.	·000
„ 21	30·098	58·0	48·3	·490	·72	71·7	43·1	28·6	0, 0, 4	NE by N, ENE, ESE.	·000
„ 22	30·107	61·8	36·1	·555	·42	73·7	44·9	28·8	0, 0, 0	NE, E by S, E by S.	·000
„ 23	...	...	...	...	...	73·7	41·3	32·4	...	... ...	·000
„ 24	30·223	56·7	44·7	·468	·66	69·0	40·1	28·9	0, 0, 0	NE, NNE, E.	·000
„ 25	30·178	54·1	38·1	·429	·58	66·3	36·2	30·1	7, 4, 0	—, NNE, NW by N.	·000
„ 26	30·109	64·0	40·5	·597	·45	74·5	38·4	36·1	0, 3, 5	—, NNE, N.	·000
„ 27	30·043	67·3	42·5	·665	·43	76·4	45·1	31·3	0, 0, 0	—, WSW, W by S.	·000
„ 28	29·945	57·0	44·6	·473	·66	70·7	42·2	28·5	4, 6, 0	NNE, NNE, ENE.	·000
„ 29	30·040	43·5	32·6	·298	·68	50·8	39·9	10·9	6, 0, —	E, E, —.	·000
„ 30	...	...	...	...	...	50·9	35·2	15·7	...	... ...	·000
Daily Means.	30·099	53·8	43·1	·434	·71	...	...	21·6	...	...	0·449

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—April, 1865.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Hourly Means.
Hour.																															
12	8	4	15	7	9	7	14	2	1	2	3	5	2	3	9	7	16	1	0	20	11	8	6	9	7	0	1	7	20	18	7·4
A.M. 1	8	3	17	6	10	10	14	1	0	0	3	3	1	5	8	5	9	1	2	13	10	8	5	6	7	1	1	5	20	12	6·5
2	9	3	14	5	8	10	9	3	0	1	2	3	2	2	6	5	10	2	4	7	10	6	6	8	6	1	0	4	21	12	5·9
3	6	4	12	4	9	12	9	0	0	3	2	3	2	4	9	5	12	3	8	13	10	9	8	6	6	3	1	5	21	14	6·8
4	6	5	8	2	11	14	6	2	1	2	1	5	3	5	9	7	16	1	10	14	11	5	8	4	5	3	1	5	24	11	6·8
5	4	1	8	2	7	13	9	3	0	2	1	2	0	5	6	5	9	3	10	12	11	5	9	6	7	3	2	6	17	12	6·0
6	3	4	10	3	10	12	9	3	1	1	2	3	2	5	9	6	10	3	10	14	13	6	9	10	6	3	3	8	15	13	6·9
7	7	0	13	3	13	12	12	1	1	5	4	5	0	4	14	10	12	3	10	12	12	12	10	7	6	4	2	3	10	24	7·7
8	5	1	14	2	13	11	12	2	2	10	2	5	3	2	12	10	11	6	10	10	13	11	11	14	5	6	3	6	26	27	8·8
9	10	2	13	1	16	14	15	1	4	7	3	6	2	3	13	9	9	5	11	12	12	12	12	15	5	5	3	7	30	27	9·5
10	12	1	14	5	17	19	13	3	7	7	3	13	4	2	12	13	7	6	12	12	13	12	12	13	7	7	2	11	32	27	10·6
11	9	5	14	3	18	17	12	4	5	8	5	17	8	4	11	20	9	7	14	14	14	13	15	15	7	8	7	13	28	26	11·7
12	12	7	15	5	17	20	10	5	7	9	4	17	11	3	14	25	8	4	15	14	16	10	15	15	9	8	7	10	32	27	12·4
P.M. 1	8	5	14	9	12	21	10	5	8	7	2	20	9	2	13	25	9	8	12	14	18	12	13	14	7	9	7	9	29	24	11·8
2	12	14	14	8	13	23	10	8	8	6	3	20	14	2	12	30	10	6	14	15	16	14	13	14	6	8	8	8	31	24	12·8
3	13	17	15	10	10	16	10	7	7	10	10	20	16	4	11	30	9	5	12	14	16	19	12	14	6	7	7	14	33	22	13·2
4	12	16	15	10	8	18	9	5	8	10	15	16	16	2	12	28	8	13	12	14	16	15	10	14	5	6	7	25	35	23	13·4
5	8	12	16	9	8	19	8	6	12	8	13	14	15	5	12	22	5	13	11	14	16	12	10	14	7	6	6	26	29	19	12·5
6	5	10	18	11	8	17	5	5	10	6	12	13	13	11	10	18	6	11	15	14	8	11	5	12	3	6	6	22	28	18	11·2
7	5	7	10	13	5	12	5	5	5	11	6	9	7	13	10	21	5	10	16	12	9	12	10	11	3	4	8	20	27	14	10·2
8	4	6	13	10	6	10	5	1	3	12	4	13	7	13	8	22	6	8	14	13	5	6	7	6	3	8	15	24	26	12	9·6
9	3	6	15	10	10	10	4	2	2	11	3	7	6	10	7	20	10	5	18	10	8	1	5	6	4	5	12	23	20	8	8·7
10	6	12	10	13	6	10	4	2	2	5	8	9	4	11	5	24	9	3	17	10	7	4	6	5	3	4	10	25	21	9	8·8
11	2	13	5	9	7	11	5	3	1	4	5	3	3	9	6	13	4	1	18	9	9	5	9	9	2	1	9	20	20	10	7·5
12																															
Total Daily Movement.	177	158	312	160	251	338	219	79	95	147	116	231	150	129	238	380	219	128	275	306	284	228	226	247	132	116	128	306	595	433	9·4

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1865. Day of Month.	Reduced to mean of day.		Calculated.			Temperature of Air.			At 9·30 A.M., 2·30 P.M., and 5 P.M. respectively.		Rain—read at 10 A.M.
	Barometer, corrected to Temp. 32°*	Temperature of Air.	Dew Point.	Tension of Vapour.	Relative Humidity.	Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	Proportion of Sky clouded.	Direction of Wind.	
	inches.	°	°	inch.		°	°	°	0—10		inches.
May 1	29·941	49·9	40·2	·372	·71	58·7	33·1	25·6	10, 10, 7	SE, SW, SW.	0·000
„ 2	29·977	56·3	45·4	·462	·69	64·2	45·5	18·7	9, 7, 5	SSW, SW, SW by S.	·075
„ 3	29·841	58·7	46·1	·501	·65	66·3	43·7	22·6	5, 5, 10	SW by S, S by W, S by W.	·002
„ 4	29·848	53·7	52·1	·423	·95	61·7	51·4	10·3	10, 10, 10	SSW, S, S by E.	·055
„ 5	29·674	59·6	50·2	·516	·73	70·0	53·7	16·3	7, 9, 10	S, SSW, S.	·171
„ 6	29·972	55·2	42·8	·445	·65	66·3	46·8	19·5	4, 7, 4	SW by W, WSW, WSW.	·046
„ 7	...	...	...	...	...	58·3	38·7	19·6	...	...	·000
„ 8	29·889	55·3	47·1	·447	·76	65·7	38·3	27·4	7, 7, 3	WNW, NE by N, N by E.	·400
„ 9	29·614	58·0	52·2	·489	·82	67·7	49·1	18·6	9, 6, 7	SW, SSW, SW by S.	·143
„ 10	29·502	43·9	44·9	·302	1·00	50·7	46·3	4·4	10, 10, 10	NW, NNW, N by E.	·719
„ 11	29·646	42·6	40·5	·289	·93	50·1	43·6	6·5	10, 10, 10	NNW, NW, WSW.	·465
„ 12	29·881	47·5	40·0	·342	·77	57·7	44·5	13·2	10, 7, 6	SW, SW by S, W.	·135
„ 13	29·984	52·5	36·5	·406	·58	62·0	38·8	23·2	6, 4, 7	SW, SW by W, SW by W.	·000
„ 14	...	...	...	...	...	57·0	47·0	10·0	...	...	·094
„ 15	29·622	49·5	46·3	·367	·89	57·3	43·6	13·7	10, 9, 7	SSE, SW, SW by S.	·026
„ 16	29·835	49·8	39·6	·371	·70	57·5	37·8	19·7	8, 9, 8	SSW, SW, SSW.	·008
„ 17	29·900	53·2	46·0	·416	·78	62·7	43·8	18·9	10, 9, 9	S by W, SW by S, SSW.	·020
„ 18	30·121	54·0	38·5	·427	·59	62·7	45·8	16·9	4, 3, 2	NW by N, N by W, NW by N.	·001
„ 19	30·331	59·3	43·1	·511	·58	68·6	41·3	27·3	1, 1, 2	SSW, WSW, W by N.	·000
„ 20	30·289	61·8	39·3	·555	·46	69·7	45·9	23·8	7, 0, 0	ESE, E, E.	·000
„ 21	...	...	...	...	...	78·7	52·6	26·1	...	...	·000
„ 22	29·939	65·8	54·5	·633	·69	73·7	53·3	20·4	2, 2, 2	—, S, S.	·644
„ 23	29·977	61·7	54·8	·553	·80	71·8	51·3	20·5	5, 2, 10	SSW, SSW, WSW.	·002
„ 24	30·063	58·2	48·0	·492	·71	66·0	48·9	17·1	7, 5, 2	S, SSE, —.	·190
„ 25	30·112	59·4	48·5	·512	·69	69·9	45·1	24·8	2, 3, 3	—, S by E, S.	·000
„ 26	29·976	64·4	50·8	·604	·63	72·7	42·3	30·4	1, 5, 1	SE by S, S by E, SSE.	·000
„ 27	29·878	61·6	48·7	·551	·65	69·3	52·6	16·7	3, 2, 2	SW by S, WSW, SW.	·000
„ 28	...	...	...	...	...	66·7	54·7	12·0	...	...	·084
„ 29	29·882	61·4	54·9	·548	·80	70·8	52·3	18·5	10, 8, 9	SW, SW, S.	·000
„ 30	29·845	56·9	39·6	·471	·55	65·6	55·3	10·3	5, 7, 10	SW by W, WSW, WSW.	·000
„ 31	29·922	57·8	45·4	·486	·65	67·6	49·3	18·3	8, 7, 8	W, —, SW.	·000
Daily Means.	29·906	55·8	45·8	·462	·72	...	...	18·4	...	...	3·275

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—MAY, 1865.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Hourly Means.
Hour.																																
12	8	9	5	17	4	11	0	1	12	8	10	11	6	5	4	7	7	8	5	4	10	0	1	7	2						6	6·5
A.M. 1	6	6	5	14	2	9	1	2	13	10	11	10	4	6	2	7	6	7	2	4	10	3	1	8	3						5	6·0
2	5	8	5	11	7	12	1	4	16	9	10	10	4	9	1	6	7	5	4	1	6	1	4	8	3						4	6·2
3	4	9	3	10	9	12	1	1	14	7	6	8	1	6	1	6	7	3	4	0	10	1	1	8	2						5	5·3
4	3	11	3	9	11	9	2	1	16	8	5	9	3	7	3	6	12	5	3	1	7	1	2	8	2						5	5·8
5	3	9	4	9	11	6	1	1	10	7	5	11	2	7	1	6	15	3	2	1	8	6	1	7	2						5	5·5
6	6	13	8	7	10	13	1	1	6	8	7	13	5	10	1	8	15	4	1	2	10	9	2	6	0						6	6·6
7	9	15	18	9	10	14	7	2	5	6	7	14	16	10	2	12	13	6	3	6	10	6	8	4	4						8	8·6
8	5	20	13	11	12	13	14	5	5	6	10	15	17	8	3	14	10	7	0	6	9	4	5	6	3						8	8·8
9	7	23	29	13	20	14	15	3	8	6	9	16	13	7	4	14	14	7	0	4	6	3	10	8	4						5	10·1
10	8	23	30	13	17	16	19	3	13	4	9	17	14	9	7	15	21	7	6	8	5	7	7	12	6						7	11·6
11	16	21	26	11	21	13	13	4	15	3	6	20	13	8	13	13	23	9	6	9	6	5	5	15	6						6	11·8
12	10	24	28	9	20	13	18	4	13	5	7	20	14	8	13	14	28	7	10	9	5	11	5	12	*						5	12·5
P.M. 1	9	25	26	13	19	11	20	9	11	4	6	20	12	6	13	15	24	10	9	11	5	12	6	8							5	12·3
2	9	29	25	15	20	12	18	8	14	5	7	21	10	5	25	15	22	10	9	13	7	11	8	9							9	13·4
3	11	28	22	11	20	14	5	9	12	6	4	22	11	1	21	15	19	9	8	12	10	10	9	17						*	5	12·4
4	8	30	20	14	12	9	16	14	12	5	6	13	9	4	25	17	20	10	9	10	12	9	17	13						15	5	12·8
5	7	22	17	12	8	13	15	11	8	5	7	14	5	3	18	17	18	8	7	8	11	10	10	7						15	6	10·8
6	10	16	20	8	7	9	10	10	7	6	6	13	3	3	12	14	17	6	6	10	8	10	8	4						10	8	9·3
7	5	15	14	13	10	5	6	5	2	10	5	17	1	8	8	10	14	4	2	7	4	6	11	5						13	6	7·9
8	4	12	12	7	11	5	6	5	1	8	5	14	0	5	7	10	14	2	1	7	3	4	8	1						8	3	6·2
9	6	5	12	4	11	5	3	5	1	9	10	8	2	6	8	11	13	2	2	4	1	3	9	2						8	1	5·8
10	10	3	19	4	14	2	2	11	2	11	9	8	6	5	7	7	9	2	5	12	2	2	9	2						8	2	6·7
11	10	3	20	3	13	3	1	12	2	11	11	6	7	4	7	7	10	4	2	11	2	0	7	1						6	1	6·3
12																																
Total Daily Movement.	179	379	384	247	299	243	195	131	218	167	178	330	178	150	206	266	358	145	106	160	167	134	154	178						126	8·8

* No record from May 25th to 30th, Anemometer undergoing repair.

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1885.	Reduced to mean of day.		Calculated.			Temperature of Air.			At 9·30 A.M., 2.30 P.M., and 5 P.M., respectively.		Rain—read at 10 A.M.
Day of Month.	Barometer, corrected to Temp. 32°.*	Temperature of Air.	Dew Point.	Tension of Vapour.	Relative Humidity.	Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	Proportion of Sky clouded.	Direction of Wind.	
	inches.	°	°	inch.		°	°	°	0—10		inches.
June 1	29·816	54·2	47·4	·430	·79	64·0	49·3	14·7	4, 10, 10	ESE, E, E.	0·000
„ 2	29·659	49·9	51·4	·372	1·00	59·4	53·3	6·1	10, 10, 10	SW, SW, WSW.	·910
„ 3	29·962	56·3	52·7	·462	·89	67·4	51·9	15·5	10, 9, 1	SW, W by N, W.	·165
„ 4	...	...	...	...	...	69·7	51·3	18·1	...	... ...	·006
„ 5	30·323	61·1	51·4	·342	·72	72·7	49·9	22·8	4, 3, 0	W by N, W, WSW.	·000
„ 6	30·303	65·9	58·2	·636	·78	75·3	58·0	17·3	9, 8, 10	SW by S, WNW, WNW.	·000
„ 7	30·384	59·9	50·8	·521	·73	70·8	58·1	12·7	8, 7, 6	NE, NE by E, E by N.	·000
„ 8	30·467	62·6	51·0	·570	·68	74·5	48·5	26·0	0, 2, 0	—, —, —,	·000
„ 9	30·330	67·8	55·8	·676	·67	78·4	53·5	24·9	0, 0, 1	W, —, —,	·000
„ 10	30·131	63·0	51·1	·578	·67	72·0	53·3	18·7	3, 8	NW by N, NW by N, NW by N.	·000
„ 11	...	...	...	...	...	62·1	49·3	12·8	...	... ...	·000
„ 12	30·439	54·1	38·8	·429	·59	63·9	41·2	22·7	0, 5, 2	NE, NE by N, NE.	·000
„ 13	30·396	63·1	47·8	·580	·60	74·1	46·6	27·5	0, 0, 1	NW, NW by N, N by E.	·000
„ 14	30·355	63·8	52·7	·593	·69	73·9	49·3	24·6	0, 0, 0	—, E by S, E.	·000
„ 15	30·369	61·1	52·2	·542	·74	71·4	45·3	26·1	0, 5, 2	—, NNE, NE by N.	·000
„ 16	30·391	56·1	45·4	·459	·69	65·6	51·3	14·3	8, 6, 1	NNE, NE, N.	·000
„ 17	30·341	57·1	47·9	·475	·73	67·2	49·6	17·6	4, 3, 2	NE, NE, NE by E.	·000
„ 18	...	...	...	...	...	56·7	47·7	9·0	...	... ...	·000
„ 19	30·324	55·7	48·0	·453	·77	69·6	49·2	20·4	10, 1, 0	NE, E by S, N.	·000
„ 20	30·325	64·4	44·6	·605	·51	75·7	42·5	33·2	0, 0, 0	NE by N, ENE, E.	·000
„ 21	30·306	72·8	43·4	·795	·37	83·6	42·3	41·3	0, 0, 0	—, —, S by E.	·000
„ 22	30·286	64·6	53·3	·609	·68	78·4	51·8	26·6	0, 0, 0	NE, N by E, E.	·000
„ 23	30·132	72·9	48·8	·798	·45	82·7	50·0	32·7	4, 7, 1	W by N, NNW, W.	·000
„ 24	30·159	58·3	40·8	·494	·55	67·9	58·7	9·2	3, 6, 7	N, N, NNW.	·000
„ 25	...	...	...	...	...	72·7	51·9	20·8	...	... ...	·000
„ 26	30·115	56·6	54·0	·467	·92	65·4	51·6	13·8	10, 10, 10	W. by N, W by N, WNW.	·000
„ 27	30·168	62·3	58·0	·564	·87	73·7	55·5	18·2	10, 8, 9	SW, S, S.	·000
„ 28	30·007	63·3	58·3	·583	·85	74·0	...	...	10, 9, 9	SE by E, SE by E, SE.	·000
„ 29	29·557	54·7	57·9	·438	1·00	63·3	54·2	9·1	10, 10, 10	ENE, W by N, NE by E.	·008
„ 30	29·318	52·0	54·0	·399	1·00	61·8	54·9	6·9	10, 10, 10	NNE, ENE, N by E.	·490
Daily Means.	30·167	60·5	50·6	·541	·73	...	...	19·4	...		1·579

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—JUNE, 1865.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Hourly Means.
Hour.																															
12	2	21	14	4	1	3	5	2	4	3	5	3	4	4	1	6	11	9	13	1	1	7	5	4	2	11	2	3	12	13	5·9
A.M. 1	7	19	12	3	2	5	6	1	3	1	15	4	4	3	2	7	11	9	12	3	3	6	1	3	2	8	3	5	13	10	6·1
2	9	17	10	2	2	4	3	3	5	2	9	4	4	1	2	4	13	9	11	1	1	4	1	3	2	6	4	5	11	9	5·3
3	8	15	12	3	3	3	5	1	4	1	9	6	4	1	1	11	12	9	11	1	1	4	1	6	3	6	5	4	8	8	5·5
4	7	6	11	2	1	4	3	2	5	1	9	7	4	1	1	10	14	8	7	2	1	6	1	14	4	6	3	5	7	6	5·3
5	11	9	11	4	4	3	11	2	6	2	8	7	3	1	0	10	11	10	10	2	1	6	1	14	5	9	3	5	5	5	5·9
6	19	19	14	3	6	4	10	1	5	1	13	10	3	2	1	13	13	12	10	2	1	9	4	15	6	10	3	6	7	8	7·7
7	18	17	13	3	7	3	11	2	4	5	14	10	4	5	1	11	13	12	10	1	1	6	4	14	10	10	2	6	7	10	7·8
8	25	14	10	5	8	4	9	3	5	6	13	13	3	2	3	14	12	13	11	3	2	5	5	15	11	8	3	9	9	12	8·6
9	30	20	9	9	8	6	11	2	8	7	12	11	5	4	2	20	10	13	9	3	2	7	5	15	11	7	5	9	8	13	9·3
10	31	22	7	6	7		12	2	8	10	10	12	5	5	4	18	15	15	8	7	4	6	8	15	11	7	4	11	6	12	10·0
11	26	24	7	6	8		15	4	9	12	13	13	7	6	7	15	17	13	8	5	5	5	11	13	13	8	3	12	5	10	10·3
12	27	23	7	8	8		14	6	10	11	15	13	5	7	5	19	15	14	9	6	6	6	11	15	14	5	4	10	9	13	10·8
P.M. 1	22	31	7	6	9	53	11	4	7	11	15	23	6	10	5	20	16	13	8	6	7	5	10	14	13	10	4	11	5	11	11·1
2	24	17	9	7	8		13	2	6	12	15	13	7	11	4	20	15	14	7	4	4	7	10	13	13	7	6	10	4	10	10·1
3	25	16	11	5	8		16	4	5	14	12	11	7	12	6	18	14	14	8	8	2	6	10	10	12	5	6	11	4	4	9·8
4	25	16	13	5	9	7	19	1	7	11	15	10	6	14	5	19	14	12	8	11	6	10	12	11	14	5	6	10	7	10	10·6
5	23	25	11	4	8	7	14	2	5	12	15	8	9	12	4	16	16	11	11	13	6	9	13	7	13	7	4	8	8	10	10·4
6	23	22	8	1	5	7	12	2	5	9	8	5	9	14	4	15	18	11	10	11	10	9	10	8	9	8	4	8	9	8	9·4
7	16	13	8	2	3	5	10	6	8	9	14	3	6	9	8	15	12	13	10	9	6	5	8	7	11	5	4	8	10	10	8·4
8	16	21	4	0	2	3	8	3	11	11	13	4	7	10	9	15	9	10	13	7	3	4	6	7	9	3	7	11	8	10	8·1
9	20	13	3	1	2	3	9	3	11	6	10	3	7	9	8	12	4	13	8	6	7	2	6	6	9	2	5	12	8	14	7·4
10	22	12	4	1	4	2	10	3	8	7	6	3	7	4	7	12	5	13	6	2	9	3	7	5	8	3	5	16	12	15	7·4
11	20	11	5	1	8	5	7	3	5	5	8	1	4	8	8	16	6	12	2	1	5	5	5	8	2	2	3	14	12	17	6·3
12																															
Total Daily Movement.	456	423	220	91	126	131	244	64	154	169	271	197	130	150	98	386	296	282	220	115	94	142	155	237	207	158	98	209	194	248	8·2

AIDS TO MICROSCOPIC INQUIRY.—No. VI.

The Illumination of Objects.

The right method of illuminating microscopic objects is a most important subject of inquiry. The beginner finds one of his chief difficulties in the arrangement of illuminating apparatus, and the most practised and scientific manipulators are continually occupied with questions only differing in degree from those which puzzle the student at the commencement of his career.

The object of illumination is of course to show all that the glasses employed can render visible, and to do so in such a manner as to make microscopic vision as easy and as little fatiguing as the ordinary exercise of the unaided eye. The beginner usually finds his arrangements in excess on one side or the other. Either his object is too much in the dark to be distinctly visible, or his field is flooded with so much light as to distress the eye, and render it impossible to discover delicate structure. The more experienced microscopist avoids these errors, but is apt to indulge in pet methods of illumination, and to assume, from appearances presented under peculiar circumstances, that he knows all the microscope can tell him concerning the objects he surveys.

It is well at the outset of microscopic experiments to inquire what effects illumination can produce. It is obvious that we only see objects by means of their action upon light, and we can learn whether they reflect it or transmit it, allow it to pass straight through them, or bend it out of its course. If we illuminate them with white light, and see them coloured, it is plain that they have prevented certain rays from reaching our eyes either by interception or absorption, or by sending them in another direction.

From this statement of the results that become visible when objects are under illumination, we may proceed to the consideration that if an object is of a composite structure, we may treat it so as to show the kind and degree of action which its several parts can exert upon light under different circumstances. When the microscope is employed to investigate any structure, we must arrange the illumination so as to test it in various ways. Each mode of illumination may teach us something not visible under another method, and by putting the results of various methods together, we arrive at conclusions concerning structure that either could not be reached at all, or not safely reached from any single method of optical investigation.

Apart from their form, the various parts of any small object of

a transparent description, and viewed by transmitted light, can only differ from each other by showing colour, by transmitting light in different proportions, by refracting light with different degrees of force, or by polarizing it, and thus rendering it incapable of transmission through certain bodies in all directions. We shall omit the question of polarization, and notice the other actions mentioned. Where difference of colour exists, it is very important in enabling us to distinguish one part of a structure from another. Coloured objects should be examined by white light, and care should be taken not to let it be so strong as to obliterate delicate tints. Varying degrees of transmissive power, and varying degrees of refractive power, operate within certain limits in much the same way. The most transparent portions of an object let most light through, and the least refractive bend the least light out of its straight course to our eyes. Thus the chief effect of contrast between more and less transparent parts, and more or less refractive parts of any object will be analogous—namely, that of stopping a greater or less transmission of light to the eye. Refracting bodies exert a power of dispersing or separating white light, which consists of rays of all sorts of colours, into distinct colours, according to their several refrangibilities. When this power is strongly exerted, very positive colours, as in the prismatic spectrum, appear; when feebly exerted, a slight difference of tint is noticeable, and that is all.

Suppose we have to examine a beautiful diatom, such as Arachnoidiscus, or a live transparent object, such as a rotifer, our object is to illuminate the one or the other, so as to enable nice gradations in refracting or absorbing power to be seen. The first thing to be done is to send the light in a good direction, and the second to regulate its quantity, and vary the quantity within certain limits either way. If a lamp is placed as far off an ordinary bull's-eye condenser as its focal length, it will transmit parallel rays—that is to say, its power of bending rays will just compensate or bring straight the divergence of the rays from all parts of the lamp that will fall upon its surface. Such parallel rays may be thrown upon a flat mirror, and sent up straight through our object. We have then illumination in its simplest form. We must apportion the quantity of light to the delicacy of the object; and if this is done, we shall see that some parts allow more than others to reach our eye. Careful experiments should be made in varying the quantity of light transmitted without changing its direction. The easiest mode of doing this is by means of an elegant piece of apparatus lately introduced by Mr. Collins; we mean his "Graduating Diaphragm." An instrument of this kind appears to have been made long ago by Dollond; but Mr.

Collins probably did not know this, and his plan is better. The "Graduating Diaphragm" fits under the stage like the common revolving diaphragm, and a screw movement enables the aperture to be reduced almost to a point, or opened to considerable extent. By this means it is easy to find the exact quantity of light that gives prominence to the most transparent portions of an object, and then to add more light until its more opaque parts transmit what they can. In the absence of this instrument, which we strongly recommend all microscopists to adopt, the gradations of light should be obtained by other means, such as using the ordinary diaphragm, turning the lamp higher or lower, interposing screens of paper rendered partially transparent by spermaceti, etc., etc.

If after having gone through a series of experiments in which light is allowed to reach the object straight, or at right angles to its flat surface, and we have ascertained the effects of carefully regulating the bulk of the illuminating beam and its intensity, we next proceed to change the direction of the light, the appearances will be modified: a slanting beam will pass through thicknesses different from those which a straight beam traverses. If the slant is sufficient to cause the rays of light, in the absence of any object, to go away from our eye, and the presence of an object allows us to see them, this effect can only be produced by the refractive power of the object, or of certain portions of it. If some parts do not refract the light so sent, they will look dark, while the refracting portions will look light. We must still pay great attention to the quantity of light transmitted, and by varying the quantity we shall obtain different effects.

Slanting illumination of transparent objects may be one-sided or all-sided, or something between the two. That is, by means of various pieces of apparatus we may send a pencil of light from one direction, or from two directions, or from all sides at once, and the effects will vary in each case. Very slight changes of direction in the light pencil will cause noticeable differences in the aspect of delicate objects. For example, if we employ an achromatic condenser, we shall find that a slight change in the angle of the mirror, throwing the light up through it, will cause the appearance of diatoms, or delicate live objects, such as infusoria, to differ to the extent that certain evidences of structure come and go, as the position of the mirror is changed.

Every object examined by the microscope has an appreciable thickness, and we can easily perceive that its appearance must vary according to the angle of which the light strikes it. A very oblique light acts almost entirely on the surface, and if properly directed and regulated, can give us surface,

and often *superficial* information. If we want, after having seen the surface, to look below it, we must not allow any rays of too much obliquity to fall upon the object; but try various changes, between light sent right through it at right angles to its flat surface, and light transmitted with moderate degrees of obliquity. In such experiments the size of the illuminating pencil and its intensity both require adjustment, and although a certain best position or arrangement may be obtained, others that are on the whole worse may yet give special information necessary for the right understanding of the object.

In illuminating transparent objects, we can employ the simple mirror, the mirror with diaphragm, the achromatic condenser, or similar contrivances; but in all cases we are regulating direction and quantity of light, and nothing more. If we stop out the marginal rays of a pencil of light emerging from a lens, we are simply determining that no rays shall reach the object but such as have little divergence. If we stop out the central rays, and allow only the marginal ones to be transmitted, we are merely providing that the object shall only be lit by rays of greater or less divergence, and not by any rays that are parallel, or have a small divergence.

With objects of considerable refractive power, we may employ rays so oblique that they would escape us entirely if they were not bent up towards our eyes. The spot lens and the parabolic illumination thus give a dark ground illumination with appropriate objects. They succeed beautifully with objects of sufficient refractive power, and they fail with those that do not possess it in the requisite degree. When objects contain two substances, or the same substances in two forms, in the one case highly refractive, and in the other highly transmissive and freely refractive, the illumination that displays the one to advantage will not show the other, and any reasoning founded upon one view only will be unsound. In like manner, if two parts differ much in transparency, one illumination cannot be equally advantageous for both.

In displaying objects to our friends we should adopt a mode of illumination that is generally accommodated to their peculiarities, but in studying them by ourselves we should ring the changes upon all the modes of illumination of which they are susceptible.

The achromatic condenser, with its variety of stops, has hitherto been the most important instrument for transparent illumination; but recently Mr. Highley has introduced an invention of Mr. Webster that may wholly or partially supersede its use. This apparatus consists of a large achromatic combination, with a plano-convex lens in front of it. It is furnished with stops somewhat like the ordinary achromatic con-

denser, and gives an illumination from a high degree of obliquity to one consisting of a small pencil of nearly parallel rays. Mr. Highley is at present engaged in devising improvements in this instrument, and we shall take an early opportunity of describing its most finished form, merely saying at present that it promises to be of great service to microscopists, from its utility and comparatively small cost.

Various experimenters have tried the effects of monochromatic light. We do not know who began such trials. We commenced them several years ago by affixing flat discs of coloured glass on the flat side of an ordinary bull's-eye condenser. Probably very small pencils of light would be most successful, and Mr. Collins' "Graduating Diaphragm" would facilitate such experiments. Red light, as least refrangible, and violet light, as most so, would give the most conspicuous results; but there are occasions when objects are well seen on a coloured background, and we remember Messrs. Powell and Lealand making an interesting exhibition of this kind.

In our last number (page 481) we mentioned that the Abbé Count Castracane employed—as is stated, with success on diatoms—Foucault's heliostat and a prism of large dispersion. For the *Pleurosigma angulatum* he found a blueish green light the best. As a rule, we should distrust the effects produced in the glare of sunlight illumination, but there are occasions when some observers consider it may be used with advantage.

In illuminating opaque objects the direction of the light is highly important. A pleasing instance of this occurs in the display of the mineral called hyperstene. A ray of nearly perpendicular light makes this object look as unlovely as a piece of coal, while one of exactly the right slope brings out gorgeous colours, often arranged like a series of Chinese pictures of landscapes and rivers. Mr. Sorby found in some of his important researches that the structure of certain objects could only be made out by nearly vertical illumination, and Messrs. Smith and Beck constructed some apparatus adapted to this want. For ordinary purposes a side silver reflector, which is best mounted on a separate stand, is an admirable illuminator, as it enables the operator to transmit rays of varying obliquity, though none as vertical as in the arrangement just described. There has been a tendency of late years to undervalue the lieberkuhn, but this is a mistake. It can be used well with object-glasses from one inch to a quarter, if not focussing too close, and by varying the position of the mirror the light may be condensed more strongly on one side than on the other. It would probably be worth while trying the experiment of limiting the size of the pencil of light reaching a lieberkuhn by

means of Mr. Collins' "Graduating Diaphragm," or by some other contrivance.

Those who have contented themselves with ordinary modes of illumination will be surprised at the variety of effects to be produced with the same slide by different methods of lighting it up. As a mere source of amusement, nothing can be pleasanter than to spend an evening or two in trying experiments of this kind. Very transparent objects should be tried with different-sized pencils of light, composed of rays either very divergent, or nearly parallel, and with all grades of intensity. Highly refractive objects, which are at the same time good reflectors, such as many of the polyparies of compound polyps (*Sertularia*, etc.), or plyzoaries (as the abodes of compound associated polyzoa have been called), are very fit for experiments, with varying angles of opaque illumination obtained by bull's-eyes, lieberkuhns, or side reflectors, and also for other experiments with spot lenses, parabolic illuminators, or the dark ground stops of Webster's condenser. All the large diatoms, hairs of animals mounted in Canada balsam, parts of insects, etc., should be treated in the same way. Many objects are nearly equally fit for transparent, opaque, and dark ground illuminations, and, as we have before remarked, an inferior mode of illumination often brings out some specialty which a better mode fails to show.

In all these experiments it must be remembered that the appearance produced may vary greatly, according to the angle at which the illuminating pencil reaches the object. Even with the same mode of illumination, dark ground, transparent, or opaque, projections or depressions will be seen or not seen, in proportion to the skill which the angle of an illumination is managed. An object may look flat with one illumination, and be seen to have a varied contour the moment another is employed.

THE PLANET SATURN.

It is to be regretted that the gradual opening of the ring-system of Saturn should be associated with his downward progress into the constellations of the wintry zodiac. During the last season, though the steady air of the warm June evenings permitted his features to bear a closer scrutiny than might have been expected from his position, astronomers must have longed for the clearer views of a higher altitude; and they will have still more cause for dissatisfaction for some years during his future visits to our midnight sky. This will not only be a source of disappointment to the mere ordinary "star-gazers," but to those who are anxious to use their powerful instruments in exploring the mysteries of this most mysterious system. Poulkowa will be entirely *hors de combat*, and even Harvard much less qualified than it formerly proved itself to deal with those minute details, on the correct perception of which the interpretation of the larger features will probably be found to depend. The necessity of future scrutiny is sufficiently evident, and in this impatient age we are little disposed to acquiesce in the long delay that must elapse before that slow revolving planet brings round his opened ring at a suitable altitude above our horizon.

These observations are not so much prompted by the recent withdrawing of the planet into the evening twilight, as by the appearance of a remarkable work, bearing the title of *Saturn and its System*,* which is well deserving of the study of those who feel an interest in this wonderful object. The book is constructed on a most comprehensive plan, embracing both the mathematical and physical aspects of the subject, discussing at great length many of the curious questions which so naturally arise out of it, and comprising a great number of elaborate tables, which seem to have been prepared with extreme care. Although, however, it contains a great deal which it would give much trouble to find elsewhere, and some things which appear to us of a very original character, we cannot say that nothing has been omitted which might be expected in a really complete and exhaustive monograph, especially in regard to details of physical structure. Here we cannot but feel the want of a more extensive recognition of the results obtained by the best authorities of the present day. No allusion, for instance, has been made to the singular distortion of the outline of the shadow of the ball upon the ring, so apparent in the designs of De la Rue, Lassell, Bond, and Secchi, and so difficult to be

* *Saturn and its System.* By Richard A. Proctor, B.A. Longman and Co. 1865.

accounted for on any supposition consistent with the extraordinary flatness and thinness of the shaded body. Nor is any reference made to the alternate difference of colour remarked by Lassell in the two ends of the "crape veil," nor to the researches of De la Rue as to the eccentricity and irregular breadth of the several portions of the ring, or the deviation of the dusky ring from the plane, or planes, of its neighbours. Besides these omissions, a few inaccuracies might be pointed out here and there; and we should have been altogether better pleased with a fuller system of reference to original authorities. But we should be sorry to detract from the general merit of a book in which, if the reader does not find everything which he might expect from its title, he will certainly meet with much that will repay the perusal, to say nothing of the very clear and beautiful illustrations which accompany it; some of which, however, would have been improved by a closer following of De la Rue's exquisite portraits.

The student may probably be most struck by the hypothesis which, in consequence of the researches of Mr. Maxwell (author of the Cambridge Prize Essay on this subject in 1857), the writer has adopted as the most plausible explanation of the structure of Saturn's ring. It is composed, according to him, of a dense flight of satellites, so closely grouped as to escape individual recognition at our great distance, yet revolving each in its separate orbit in such a manner as to secure the general permanency of the system. This idea, which is of considerable antiquity, being at least as old as the time of Cassini II., is much less fanciful than might be supposed by any one unacquainted with the difficulties of the subject. For though the telescopic aspect of the ring produces unquestionably the impression of continuous solidity, and this would seem to be indicated by its black shadow upon the ball, yet on recognized dynamical principles that condition is found to be impossible. We may perhaps be excused for not assuming as confidently as Mr. Proctor has done, that the period of the ring's rotation is determined beyond all doubt; our impression being rather that the evidence from which it has been deduced is somewhat slender; but the fact of such a rotation seems necessarily implied by its continuous existence under the power of gravity. Whatever period, however, we assume for the rotation, it cannot theoretically suit the whole breadth of the ring, each appreciable portion of which would require a distinct time of rotation, in proportion to its distance from the planet. And hence, had it been supposed originally solid, it would have been torn asunder by the strain, and broken up into an assemblage of minute concentric rings, or, as Mr. Proctor prefers to think, into an immense mass of distinct satellites.

This is more comprehensible when we take into account the extraordinary thinness of the ring, assumed by him at 100 miles, but reduced by Bond to less than 40. With its breadth of some 26,000 or 28,000 miles, it is very conceivable that, as Mr. Maxwell has asserted, it would be "not only plastic but semi-fluid under the forces it would experience," even if it were made of iron! The American theorists had preferred the hypothesis of its consisting of a number of streams of fluid a little denser than water; and the supposition has even been entertained, and might we believe be maintained with some plausibility, that it is of a vaporous nature. The fact is—and we think it would be most readily admitted as such by those who have most closely examined the object—that it is extremely difficult to form any idea of its real nature from observation; and so long as that is the case, it offers a wide field for the admission of dissimilar theories. The existence of the inner dusky ring Mr. Proctor refers to thinner strata of satellites, which have been detached by the attraction of the globe from the more luminous mass, without ceasing to circulate round it. But, whatever may be thought of this speculation as applied to the bright rings, we must say that it appears to us inadmissible here. Without laying too much stress on the circumstance that the inner edge of the luminous ring is usually much more clearly distinguished from its darker neighbour than might be expected on that supposition, we must think that the aspect of the dusky ring in front of the ball is quite inconsistent with it. In such a position, the existence of a thinly scattered stream of light-reflecting satellites would be barely, if at all, perceptible in the most powerful instruments, instead of its challenging the eye so distinctly, even in smaller ones, as a dusky zone, that it has been sometimes even mistaken for the shadow of the bright ring. Mr. Proctor's hypothesis would naturally be connected, as he has shown, with such a decrease in the dimensions of the ring as has been attempted to be proved by Otto Struve from a comparison of the older and more recent drawings and measurements; but he has not adverted, as might have been expected, to the circumstance that in consequence of the very careful investigation of Mr. Main, Struve's result has not received the general concurrence of, at least, the astronomers of England.

We might enter into further detail, but this may suffice. Our readers will have inferred our conclusion, that, notwithstanding much diligent study and praiseworthy labour, the subject is still not exhausted, and requires, as it deserves, to receive a more extended elucidation. But for this it will be better to wait till future observation has supplied more satis-

factory materials for theory. And we must not forget that, though any essential advance may for some years to come be denied to Europe and the United States, yet there are Southern observatories which will not, we hope, be idle during the increasing expansion of the ring. We have heard with much regret, and trust it may prove to be an unfounded report, that Mr. Lassell's munificent offer of his 4-foot reflector has been declined by the authorities at Melbourne. But should this unfortunately prove true, we trust that they will feel the obligation they have incurred, to do something which may prove that the course which they have adopted was not the result of indifference to the progress of astronomy.

The telescopic researches into the structure of Saturn and his appendages, which are very imperfectly traced, or omitted, by Mr. Proctor, are so important and interesting, that our first intention was to embody an account of them in this paper; but, upon further consideration, we thought it best to postpone this inquiry, in the hope of recurring to it in a separate article at no very distant time. The numerous contributions to this branch of observational astronomy by Mr. De la Rue would, in themselves, demand a longer and more careful treatment than we could give them at the present moment; and it would be necessary to collate and compare them with the researches of other eminent observers to whom allusion has been made. Another reason for deferring the consideration of this subject is, that it has been suggested to us that it would be more welcome when Saturn is returning to our skies, than when he is passing away from our view.

LITERARY NOTICES.

ICE CAVES OF FRANCE AND SWITZERLAND: A Narrative of Subterranean Exploration. By the Rev. G. F. BROWNE, M.A., Fellow and Assistant Tutor of St. Catherine's College, Cambridge, Member of the Alpine Club. (Longmans).—So little is generally known concerning even the existence of those curious natural objects—ice-caves, or *glacières*—that Mr. Browne's pleasantly-written narrative of his explorations will have the charm of complete novelty to most of his readers. The general conditions of an ice-cave are, first, the existence of a great hole in the ground, at a considerable elevation. The cave must be protected by its shape and local conditions, not only from direct solar radiation, but also from the entrance of warm currents during the summer months; and lastly, there must be, from infiltration or some other cause, a supply of moisture to be frozen when a sufficiently low temperature prevails. Thus, the *glacière*, or ice-cave, is an ice-factory and ice-house combined. During the greatest heat it must not be so affected by the external air as to reach, for any length of time, a temperature much above the freezing point. There may be a little thaw; but there must not be enough to prevent a good stock of ice remaining till the period of fresh ice formation comes round again. The traveller desiring to visit these very curious natural formations climbs a few thousand feet up some mountain slope, then finds a more or less abrupt entrance to a cave, which he usually descends, partly by means of ricketty, half-rotten ladders, and partly, when the slope admits of it, by the help of steps cut in the ice. In Mr. Browne's case he was accompanied in many explorations by two adventurous sisters, who braved the difficulties and dangers of subterranean travelling, and seem to have got on famously, when divested of crinoline. Walls of ice, sheets of ice, stalactites and stalagmites of ice, columns of ice, and ice in a thousand fantastic forms gratified the explorers, and Mr. Browne's descriptions, in addition to their scientific value, form a very readable volume, likely to tempt many of his fellow-creatures into leaving the sunny regions of the day, and plunging down into the damp, cold bowels of the earth, at the risk of rheumatism and catarrh. Mr. Browne himself prudentially dined and cooled outside the ice-caves before encountering their dark and wintry depths, and his brave sisters very wisely compounded wholesome prophylactics, by mingling brandy with ice or snow.

Some *glacières* are reached by first descending a deep pit, others begin with a slope, more or less impracticable. In the case of the "Glacière of Monthezy," after scrambling down rough, steep, and wet rocks, the party came to an "abrupt slope of mud," and "a buttress of damp earth," in which it was necessary to cut deep holes for the hands and feet before even a man could venture upon the attempt with comfort." The man and the praiseworthy women who could find "comfort" under these circumstances, certainly deserved the reward of something worth seeing when their labours were done, which, however, was far from

being the case after the mud part of the passage was accomplished. That merely brought them within sight of a ladder twenty-one feet deep, and having only seven steps. The cave had other entrances which were worse, and so the ladder descent was made, and conducted the explorers to a low entrance, from which a strong cold blast was blowing. The greater part of the cave was too low to admit of standing upright, and was, of course, quite dark; but there were three domes, beneath which the erect posture could be changed for the reptilian mode of progression over the cold, sloppy floor. We can understand that the adventurers "hailed with delight" one of these domes, and "this delight was immensely increased when our candles showed us that the walls of this vertical opening were profusely decorated with the most lovely forms of ice. The first that we came under passed up out of sight, and in this two solid cascades of ice hung down, high overhead, apparently broken off short, or at any rate ending very abruptly; the others did not pass so far into the roof, and formed domes of very irregular shape. In all three the details of the ice decoration were most lovely. . . . The candles in our hands brought out the crystal ornaments of the sides, flareing fitfully all round us and overhead, as if we had been surrounded by diamonds of every possible size and setting." In another dome "on every side were branching clusters of ice, in the form of club mosses, with here and there varicose veins of clear ice, and pinnacles of prismatic structure, with limpid crockets and finials." Many other ice-caves explored by Mr. Browne were equally curious with that of Monthezy, and what we said concerning his book will, no doubt, determine our readers to consult its pages for themselves.

On Radiation: The Rede Lecture, delivered in the Senate House, before the University of Cambridge, on Tuesday, May 6, 1865. By John Tyndall, F.R.S., Professor of Natural Philosophy in the Royal Institution, and in the Royal School of Mines. (Longmans).—This is an excellent summary of the leading facts concerning the radiation of light and heat, absorption, etc. It is written in Professor Tyndall's well-known interesting style, and is characterized by his usual power of making a difficult subject intelligible, by approaching it gradually and in the right way.

A Dictionary of Science, Literature, and Art: comprising the Definitions and Derivations of the Scientific Terms in general use; together with the History and Descriptions of the Scientific Principles of nearly every branch of Human Knowledge. Edited by W. F. Brande, D.C.L., F.R.S., L. and E. of Her Majesty's Mint; and the Rev. George W. Cox, M.A., Late Scholar of Trinity College, Oxford. (Longmans.) Parts III. and IV.—The first volume of the new edition of this work is completed by Part IV., and on the whole it appears to us very well calculated to answer the purpose described in the preface, namely, that of providing a cheap cyclopædia, containing a well-selected series of articles. Of course, in order to keep down bulk and price, many things must be omitted that ought to be found in larger and more costly works;

but there are thousands of families and students who will be glad of such a work as is now offered, and in extending it to three volumes the editors have, in our opinion, acted wisely. It enables them to take a middle position between prolixity and incompleteness, and for many years to come the new edition will occupy an important place amongst really serviceable books.

Comparative Geography. By Carl Ritter, Professor of Geography in the University of Berlin. Translated by W. Gage. (Blackwood and Sons.)—This publication brings within reach of English readers a very valuable course of lectures on comparative geography, by the late Carl Ritter, who occupied the highest place in this branch of science. It describes the surface of the earth in its most general relations, and then proceeds to special considerations, such as the contrast of land and water hemispheres, the historical element in geography, plateaus, mountains and mountain lands, plains, lowlands, courses of rivers, etc., etc. It is one of those admirable works that suggest a philosophy as well as provide facts, and will form a valuable addition to the well-selected family library.

The Anthropological Review, No. 9 and 10. (Trübner and Co.) —In the last number of this publication of the Anthropological Society will be found the papers attacking missions and missionaries, which created a sensation in the religious world, and also the remarkable defence of missions by Bishop Colenso. The Anthropological Society has made itself very notorious, and now boasts of some six hundred members, which is a great success, so far as numbers are concerned. During the American war, when philanthropists hoped that that terrible struggle would eventuate, as it has done, in the abolition of slavery, the Society ran a-muck at the negroes, as though a reckless and heartless abuse of black men was the chief duty of the time. Such conduct, of course, made a sensation, and when that sensation was subsiding, another was got up, by assailing missionaries and their converts. Neither in the negro case nor in the mission case was there anything like scientific accuracy, or sobriety of discussion; and though the Anthropologists have certainly become notorious, their scientific reputation is yet entirely to be made, and if it is ever made, their mode of operations must be entirely changed. We should certainly not condemn them for bringing forward unpalateable truths. If too much capacity for civilization is assigned by many benevolent people to the negro race, let the error be exposed; and if too much is claimed on behalf of missionary action, let a more exact estimate be made; but a scientific society ought to avoid the recklessness and rancour that characterize too many political and theological disputes. To single out the negro race, as if no other race was difficult to civilize, was obviously unfair; and to speak as if missionary efforts were the only or most remarkable instances of failure on the part of the white man to improve black men, is to show a similar disregard for accuracy, if not for truth. The fact is, that our civilized races are nearly uniformly unfortunate in their dealings

with races occupying an inferior position. When they came into contact with an inferior race, their tendency is to destroy it rather than to elevate it, and neither merchant nor missionary succeed in producing those extensive changes for good which we think ought to be the result of civilization acting upon comparative barbarism. If the Anthropological Society can tell us how to improve existing methods of teaching industry, and morality, and religion, their services will be welcomed; but indulging in throwing stones at other folks contributes in no wise to this end.

ENTERPRISE AND ADVENTURE, being the second volume of the "Temple Anecdotes." (Groombridge and Sons.)—The present volume of this capital series consists of a very numerous and interesting collection of original articles, embodying the best stories of enterprise and adventurous exploration. The editor conducts his readers to sojourn with Belzoni in Egypt, with Dr. Wolff amongst the Affghans, with Huc and Gabet to Tartary, with Humboldt to the banks of the Orinoco, and with Markham in Peru, and deals in like manner with many other travels and travellers of importance and fame. The selection and treatment of the subjects is alike judicious, and thus this portion of the "Temple Anecdotes" provides a fund of exciting reading, in which the stimulus is of a thoroughly wholesome kind. Literature of this class can be honestly recommended, as calculated to rouse the young to a perception of the great fact, that the real dignity of life consists in its noble sentiments and in its useful work.

HARDY FERNS: HOW I COLLECTED AND CULTIVATED THEM. By MONA BELLAIRS. With a Frontispiece. (Smith, Elder, and Co.)—Miss Bellairs has wisely provided herself with an object in her pleasure trips, and she discourses in a lively manner concerning her expeditions in various parts of the three kingdoms in search of ferns. Her book is very prettily got up, and will no doubt stimulate others to follow her example. Most of her advice is very good, but we should not like to promise much success to any one who made a fernery in a place as much exposed to sun as she recommends. Most ferns fitted for out-of-door growth in this climate like warmth, but they like it as they get it in their favourite haunts, which are seldom exposed to the noontide blaze.

A HANDBOOK OF BRITISH PLANTS. Designed especially for Schools, Senior Classes, and Excursionists. By G. LOWNDES NOTCUTT, Author of *Handbook of the Microscope*, *The Geography of Plants*, etc. (Longmans.)—Mr. Notcutt explains in his preface that he has no intention of competing with the larger floras of Babington, Hooker, and Bentham, but intended to produce a portable introductory volume, which could conveniently form a pocket companion for the excursionist, or a handy text book for the student. The book begins with a brief analysis of natural orders, then we have a description of genera, and lastly a descriptive list of species. In each division the student is led on by the method of agreement or discrepancy now employed by all the best botanists. Having ascertained the order of a plant, the list of genera is to be

consulted, looking down the descriptions until one is found to fit. Then the list of species is resorted to in the same way. Mr. Notcutt appears to have compressed a great deal of information into a small space, and his method is clear.

ARCHIVES OF MEDICINE. Edited by LIONEL S. BEALE. Vol. IV. (Churchill.)—The most important papers in this number relate to the controversy raised by those who dispute Dr. Beale's statements that nerves never end in free extremities, but always form closed circuits. We have in former numbers expressed our admiration of Dr. Beale's skill as a microscopical manipulator and observer, and we believe that his main positions will be sustained by fair investigation. Those physiologists, however, who employ very inferior methods of preparation, and examine their objects with powers bearing no comparison with his superb lenses by Powell and Lealand, are really not entitled to be heard against him. Before they ask us to attach any importance to their not seeing what he sees, they must put themselves in a condition in which seeing what he describes becomes possible.

ASTRONOMICAL INVESTIGATIONS. THE COSMICAL RELATIONS OF THE LUNAR APSIDES. OCEANIC TIDES. By HENRY F. A. PRATT, M.D. (Churchill.)—We are always desirous that a fair hearing should be given to those who controvert received opinions. The progress of science involves the constant discovery of truths that contradict preconceived ideas, and we all know that submission to authority has been the frequent means of prolonging error. Still, when any one comes forward to deny certain elementary facts which scientific men consider abundantly proved, they cannot expect that students will devote much time to their elaborate arguments, unless they show themselves right with regard to the postulates of the case. Now, Dr. Pratt seems to us, upon insufficient grounds, to deny the correctness of the received opinions concerning the flattening of our globe at the poles, and the ellipsoidal character of its orbit; and we therefore do not feel bound to attempt to follow him in his various hypotheses. The "moon controversy" has brought prominently into notice the fact, that many men of considerable talent and knowledge have not the faculty of appreciating a particular line of argument, just as certain other persons cannot hear particular sounds or see particular colours. With due respect for Dr. Pratt's ingenuity and attainments, we should place him in this category, and should despair of appreciating the grounds of his discordance with all our best mathematicians and physicists.

BACON'S HISTORICAL AND ARCHÆOLOGICAL MAP OF ENGLAND AND WALES, from the Earliest Period to the Present Time. (Bacon and Co.)—We are glad to find this map published at a price which will bring it within the general reach of students. It is coloured so as to show the boundaries of the political divisions of England in Anglo-Saxon and Danish times, and the divisions of Wales before its subjugation. The map is thickly studded with names, and will be a great assistance in realizing incidents of British history.

MALCOLM'S GENEALOGICAL TREE OF THE ROYAL FAMILY OF GREAT

Britain, from the first King of England, the first King of Scotland, and the first Duke of Normandy. (Bacon and Co.)—Though of less substantial use than the preceding, this chart is, by the price affixed, expected to be the most popular. We presume Mr. Malcolm has consulted sufficient authorities for composing his "tree," and have no doubt its exposition of royal marriages and their results will be pleasing to the curious in such subjects.

List of Diatomaceæ occurring in the Neighbourhood of Hull. By George Norman. (Hull, March, 1865.)—Mr. Norman states that his former list contained about 400 species; the present one contains 480, "a number which considerably exceeds the whole of the species given as British in Smith's work." The present list is not only a proof of the remarkable richness of Hull in objects of this kind, it is also an evidence of extraordinary industry on the part of its author.

Journal of the Scottish Meteorological Society. New Series. No. VI. (Blackwood.)—In addition to abstracts of local observations, this number contains essays of importance, among which is a paper by Mr. Alexander Buchan on the storms which occurred in Europe in October, November, and December, 1863. Mr. Buchan says:—"From the rate at which the storms passed over the British Islands a number of them could have been predicted for thirty-six hours at the more easterly British ports, a few for only twenty-four hours, but none for quite so long a period as forty-eight hours. The forms of forty-two different areas of barometric pressure were examined. Of these, thirty were circular, or nearly so, the longer diameter having to the shorter no higher ratio than that of three to two. . . . . The area over which the storms spread themselves was very variable in size, seldom less than 600 miles across, and often two or three times that amount. Occasionally, as the storm area expanded, the central depression divided into two separate depressions, which appeared to become two separate storms, with the wind circling round each.

PROGRESS OF INVENTION.

Palimpsests.—The scarcity of writing materials led, in the middle ages, to an attempt at economising them, which was attended with very mischievous results to literature. Manuscripts containing the most valuable productions of antiquity were effaced, that the parchment on which they were written might be used for some worthless legend, or some fanciful disquisition equally valueless. Various efforts have been made to revive the more ancient writing, in the hope of recovering some lost work of classic antiquity. A very effective means of attaining this object has lately been discovered by accident. An old engraving having been photographed, a line which had been written with a pen was perceived in the copy, though nothing of the kind had been observed in the engraving. An examination, however, showed that it had been there, but was

erased, under the supposition, very probably, that it lessened the value of the engraving. This discovery of another curious result of photography immediately suggested its use as a means of reviving the effaced writing of palimpsests, and it is even hoped that what is thus recovered may be transferred directly to steel or stone.

Economic Source of Oxygen.—Oxygen gas has of late become of considerable importance in the arts, etc., and it is probable that it would be employed for a still greater variety of purposes were it not so dear and difficult to be obtained. These obstacles to its more general use are not likely to exist much longer. It may be very easily and economically procured by acting on sulphate of lime at a high temperature with silex, so as to form silicate of lime, sulphurous acid, and oxygen; and conducting the gaseous mixture into a chamber where it is exposed to a pressure of three atmospheres, which liquefies the sulphurous acid. The oxygen, after having been purified by transmission through lime-water, is compressed into strong receivers. A company has been established at Paris for the production of oxygen in this way, and it is expected that the gas will be furnished so cheaply that it may be employed in the combustion of the ordinary gases for illumination, so as to render their light fifty per cent. cheaper, and at the same time get rid of certain inconveniences which necessarily arise from the mode in which they are burned at present.

New Method of Engraving.—The process devised by M. Comte for this purpose consists in coating a plate of zinc with a white water-colour, then drawing the design upon this with a fine point, so as to uncover the surface of the metal, afterwards applying a varnish which adheres to the plate only in those places which have been laid bare by the point, and then washing off the paint with water. The plate is next acted on with nitric acid, which forms hollows between the lines produced by the varnish; and thus there results an engraving *in relief*, from which impressions may be taken in the same way as from wood. This method gives the design actually drawn by the artist, requiring no intermediate hand, which, however skilful, may be incapable of faithfully rendering the intended effect.

Cure of Consumption.—Any means of curing this insidious and fatal malady must be hailed as a benefit of no ordinary value to the human race. A remedy which is stated to have this effect was brought before the Academy of Sciences, on the 12th of June. Raw beef or mutton is reduced to a pulp in a mortar, and afterwards passed through a sieve, to separate any tendinous matter. It is then made into balls, which are to be rolled in sugar, or it is merely sweetened with sugar, and administered in spoonfuls, to the amount of from one to three hundred grammes daily. The patient must use as a drink about one hundred grammes of the pulp diffused through five hundred grammes of water sweetened with sugar; also three hundred grammes of sweetened water, to which one hundred grammes of alcohol at 20° Baume have been added, are to be taken

at the rate of one spoonful every hour. The doses and intervals between them must be regulated, to some extent, by the susceptibility of the patient. The raw meat is supposed to have a reconstituent action, and the alcohol a direct effect on the hematose. Persons very far gone in consumption, and some even who could not have survived more than a few hours, are stated to have been completely recovered by this combination of curative agents.

Formation of Steel by Gases.—The process of M. Bérard for the formation of steel from cast iron consists in the alternate oxidation and reduction, simultaneously, of different portions of the cast iron. The oxidation is effected by the introduction into the fused metal of atmospheric air; and the reduction, by the introduction of a mixture of hydrogen and carbonic oxide, previously freed from sulphur. After twelve or fifteen minutes the processes are reversed; the portions which had been submitted to oxidation being then submitted to reduction, and *vice versâ*. This alternate action is continued until it is found by testing that good steel has been formed, the last process being invariably that of decarburation. The oxidation changes the metals, whether earthy or proper, into oxides; the reduction brings the iron into a metallic state; and both of them change sulphur, phosphorus, etc., into acids, which escape by the chimney.

New Application of Centrifugal Force.—The chief peculiarity of Guerin's steam engine consists in the transmission of the steam, after it has done its work in the cylinder, into a fly-wheel, the arms and rim of which are hollow; it is there condensed by a jet of cold water, and the condensed steam and condensing water are expelled by centrifugal force: or the steam is merely driven out by it. In either case the resistance which the waste steam offers to the motion of the piston is supposed to be greatly diminished, the effect thus produced being so much clear gain.

Storage of Dangerous Substances.—The terrible accidents which have recently arisen from the accidental explosion of gunpowder, and the conflagrations produced by the ignition of petroleum, etc., have caused such serious and well-grounded alarm, that an anxious consideration of the subject could no longer be deferred: and, as a natural result, measures have begun to be adopted which will greatly diminish the danger, and seriously mitigate the consequences of explosion or combustion should they occur. Floating stores have been constructed at St. Ouen, for dangerous substances. They consist of cylinders made of boiler plate, about sixteen feet high and seven in diameter, with convex tops and bottoms, and manholes. They are arranged in rows of twenty-five, are strongly bound together with iron, and are covered down to the water line with planking. They ordinarily lie out in the midst of a spacious basin; and when they are to be loaded or unloaded, are brought to the bank, pumps being used when their contents are liquid.

Casting of Metal Tubes, etc.—A new, ingenious, and very simple way of casting tubes, etc., has been invented by Auguste Larson, a young French workman. The mould is something of the form of a closed cylinder, which, however, is capable of being taken

asunder. The liquid metal is poured into this, while it is revolving with great rapidity; and the centrifugal force causes all the interior details of the mould to be perfectly and sharply filled; so that when the metal has cooled, and the mould is removed, a perfectly undistorted and smooth casting is obtained.

TURBINE BRUSH.—This simple but effective contrivance, which has been lately patented in America, consists of a circular brush, at the back of which is a small turbine wheel, supplied with water through the handle by a flexible tube attached to the latter. The rapid revolution of the brush, aided by the supply of water, causes it to act very effectively, while at the same time a perfect uniformity of wear is secured. This ingenious application of the principle of the turbine is another example of the practical nature of American inventions.

MILLER'S HELIOTROPE.—Professor W. H. Miller, of Trinity College, Cambridge, has communicated to the Cambridge Philosophical Society an account of a new form of heliotrope, intended to reflect the rays of the sun to any desired distant object by means of the hand and eye alone. In its first form the instrument depends upon the property that a ray of light falling in succession upon three plane mirrors at right angles to one another, returns upon a path opposite and parallel to its original course. If the source of light is the sun, its rays, after falling upon three such mirrors, will be returned back again to itself. At any point of their circuit rays will therefore be found going in exactly opposite directions. Professor Miller avails himself of this property to construct a heliotrope by making one mirror of the three the largest. It is coated with chemically precipitated silver, which sends a large quantity of light directly to the distant object desired to be illuminated. The other two mirrors are small pieces of unsilvered glass fastened at one corner of the larger mirror, so that they are at right angles to each other, and make right angles with two sides of the large mirror. When a ray of light falls on the large mirror, and is reflected in one direction, a second ray parallel to the first falls upon one of the small mirrors, by which it is reflected on the second small mirror, and from thence through an aperture in the large mirror in a direction parallel, but opposite to that taken by the first ray. This ray being admitted to the eye of the operator through a hole in the silver coating of the large mirror, enables him to direct the principal beam to any distant object, by hand and eye, at pleasure. Two edges of a rectangular looking-glass, if perfectly square and well polished, produce the same effect as the two small mirrors of unsilvered glass. But a tinted glass, to relieve the eye, must be applied at the back of the looking-glass, where the metallic silvering is scratched away. For the signals of a survey this form of heliotrope will probably supersede all others, from the ease of its construction, its simplicity in use, and from the impossibility of deranging its adjustments. It is made and sold by T. E. Butters, 4, Crescent, Belvedere Road.

SOLUTION OF THE ANILINE DYES.—Hitherto almost all the aniline dyes and their congeners, being insoluble in water, required for solution alcohol or methyline. The former is objectionable on ac-

count of its dearness, the latter on account of its injurious effect on the workpeople; and yet no substitute for them was discovered. M. Gaultier de Claubry has found out a very simple mode of rendering these dyes soluble in water. It may be remarked that their solution is attended with peculiar difficulties, on account of their being, in many instances, composed of constituents of very different solubility. Thus the aniline violet contains red elements which are soluble in various fluids, and blue, which are with difficulty soluble at all. During his researches, M. Claubry ascertained that there are many substances which impart to water the power of dissolving them. Thus gums, mucilages, soaps, glucose, dextrine, the jellies of different feculæ, lichens, and fuci. When, for example, Egyptian soap-wort is used, and it answers extremely well, it may be triturated with the colouring matter. Boiling water is then to be added in successive doses—each being removed before the next is added—as long as anything remains undissolved; the action of the different portions of fluid being aided by shaking, and the clear solutions obtained being removed by decantation. All the solutions must, in the end, be mixed together, as the earlier ones will take up chiefly the more soluble constituents: and thus a perfectly pure tint, quite unchanged by the process, will be obtained. The mode of proceeding may be modified in various ways. Thus, if it is considered desirable to use some alcohol, the soap-wort may be employed first, and the alcohol towards the end of the solution, or *vice versa*.

Portable Submarine Light.—The electric light has very often been used for producing illumination under water; the charcoal points being inclosed in a water-tight receiver, and the battery being placed in a boat, etc. But this arrangement is objectionable; it is very costly, the apparatus is extremely liable to disarrangement, and is difficult to be manipulated; moreover, the light, for many purposes is far too intense. M. Paul Gervais has devised a method of applying an apparatus, very similar to that proposed for use in mines,* to submarine illumination. It consists of a Geisler tube, of an appropriate form, filled with carbonic acid, and inclosed in a stout water-tight glass cylinder, and capable of being put in connection, at pleasure, with a battery and coil, which are within a water-tight case that is easily portable. In constructing this apparatus, M. Gervais obtained the assistance of Ruhmkorff, who is also at present carrying out some improvements, that are expected to render it still more practically useful. The light emitted by it is said very closely to resemble that of phosphorescent animals, except that it is more intense; even when several yards under water it can be perceived at a considerable distance. The instrument used has been kept nine hours at a time under water, and six of these in action; indeed, there does not seem any limit to the time during which it may be in operation.

* Intellectual Observer, No. xxxviii. p. 146.

IS LIGHT IMPONDERABLE?

WHAT do we mean when we speak of any object around us, and call it a ponderable substance, or one that has weight? Simply that the body in question attracts, and is attracted by the mass of our earth. No doubt it also attracts, and is attracted by, the moon, the sun, and other celestial bodies; but from their great distance their attraction is so much diminished, that we take no account of it in relation to masses of moderate dimensions. The tides result, as we all know, from the attractive force exerted upon the waters of our globe by the sun and moon; and if we could put the Pacific or the Atlantic ocean into a scale, the weight of those fluid masses, or in other words the amount of force with which they pressed towards the earth's centre, would noticeably vary, as it was more or less counteracted by opposing forces exerted by the sun and moon. The weight of bodies on the globe, or on any other planet whose form differs from a true sphere, varies according to its position. Our globe is a little flattened at the poles, and thus any body taken from the equator to either pole approaches a little nearer to the earth's centre, and is more powerfully attracted. The projecting equator, being larger in circumference than a circle near the poles, has to move faster than the latter as the earth rotates, or it would be left behind, which we know is not the case. Now the centrifugal force arising from rotation tends to throw any body off, while the gravitation attraction of the earth tends to pull it towards its centre. Hence the weight of a body, measured by the force with which it tends to the earth's centre, is diminished at any point at which the centrifugal force is increased. Thus two circumstances cause a difference in the weight of bodies moving from the equator to the poles. "Owing to the elliptical form of the earth, alone, and independent of the centrifugal force, its attraction ought to increase the weight of a body in going from the equator to the pole by almost exactly $\frac{1}{190}$th part, which together with $\frac{1}{289}$th due to the centrifugal force, makes up the whole quantity, $\frac{1}{194}$th, observed."*

Weight, then, is simply a result of attraction; and if we desire first to weigh a body at the equator and then at the poles, in order to ascertain the difference, we must obtain an invariable standard of comparison. Counterpoising it with a weight or lump of metal clearly would not do. For, suppose we had one pound of iron as the thing to be weighed, and another pound of iron as the thing to weigh it by, it is obvious

* Sir J. Herschel, *Outlines of Astronomy*, p. 150, seventh edition.

that as they counterbalanced each other at the equator they would do so at the poles, for whatever alteration in weight resulted from their change of place would affect both alike. The tension exerted by a spiral spring affords, as Sir J. Herschel points out, an illustration of a kind of force not affected by change of position; and such an instrument might enable us to compare the attraction of the earth upon a given mass in the two situations described.

These preliminary remarks may help those who have not reflected on the subject to consider weight simply as the result of attraction; and, as our instruments are all comparatively clumsy, it is not right for us to assume that a particular body possesses no weight at all because we have not succeeded in weighing it. If light be a mode of motion of some fluid, that fluid may not, as is commonly supposed, be absolutely imponderable, that is, not at all affected by the earth's attraction. We have, indeed, no right to assume that gravitation is an essential property of *all* matter under *all* conditions. Astronomers trace what we ordinarily *call* the *universality* of this force; but that it is really universal—that is to say, that it exists wherever matter exists—is more than we know. It is common to speak of light, heat, electricity, etc., as "imponderable agents," but we apprehend no thinking man is satisfied with such a phrase. If they are all modes of motion of some kind of matter, either that matter must be ponderable, or gravity only a property manifested under certain conditions.

Mr. Balfour Stewart and Professor Tait consider, in the technical language employed by the former, "that to this time it has been assumed, without proof, that the change in the co-efficient of terrestrial gravity does not in itself alter any other co-efficient of a body; and if a reason be asked none can be given, since gravity is a force of the nature of which men of science are confessedly ignorant."

Now, if gravitation acts upon light so as to have any share in determining the position of any rays emerging from a prism, and forming a spectrum, a considerable change in the position of such a prism and of such light rays, involving a change in the force of gravitation, might cause a dark line in the spectrum to take a new position, more or less differing from that which it first assumed.

When this notion was propounded to Mr. Gassiot, he acted with his accustomed liberality in the cause of science, and requested Mr. Browning to construct a "rigid spectroscope." That is, such a spectroscope that the position of any given line could be exactly measured with minute accuracy, and with the certainty that its position would not be changed by the action of heat, or by the jolting inevitable in transport-

ing the instrument from place to place. The difficulties of making such a spectroscope were very great; but they have been surmounted with marvellous dexterity and skill. A full description of this instrument will be found in the *Proceedings of the Royal Society*, No. 76.

It consists of two prisms of dense flint glass, made by Chance, and having a specific gravity of 3·9. These prisms are mounted on a bed of slate. Light reaches them through a slit, and straight through a *portion* of a right-angled prism, where the refraction is neutralized by a small prism cemented on to it. After passing through the two large prisms, and once suffering refraction and dispersion, it is sent back through them a second time by a third prism, having one side silvered, and thus it is again refracted and dispersed, one set of prisms being compelled to do double work. On its return journey, the light enters the prism over the slit and is reflected to a telescope at right angles to it, and carrying a micrometer. A series of trials in Mr. Browning's workshop, at Kew, and in the apartments of the Royal Society, have shown that the variation of the D line is quite infinitesimal, in spite of great changes of temperature and motion from place to place.

It was at first intended to send a "rigid spectroscope" up in a balloon; but the weight of the present form, and the uncertainty in balloon experiments of the prisms acquiring a uniform temperature, caused this idea to be abandoned, and Mr. Gassiot invites the Royal Society to request Her Majesty's Government to send the instrument on board some ship sailing between points on the earth's surface differing considerably in latitude, and, consequently, in the force of terrestrial gravitation. Should such experiments succeed, light must no longer be considered as the motion of an imponderable substance. Should they fail, it may still be held that success would be possible, if stations much nearer to, and much remoter from, the earth's centre, could be reached.

We must not be understood as stating that the contemplated experiments are attempts to *weigh* light; but if it can be proved that any change in the direction and force of gravitation affects the position of any line in the rigid spectroscope, the ponderability of that fluid of which light is a mode of motion might be probably assumed. Is gravitation merely a mode of force, correlative with other forces known and unknown?

ARCHÆOLOGIA.

Mr. J. T. Blight, a zealous and careful antiquary, and very clever artist and engraver, of Penzance, has contributed to the July number of the *Gentleman's Magazine* an excellent though short paper on Cornish Barrows. The barrows to which Mr. Blight directs attention in this essay are of a peculiar class, large tumuli, containing at least one rather extensive chamber, and sometimes several smaller ones, formed of massive stones, and they are found chiefly in the West of England, in the Scilly Islands, in the Channel Islands, and in Brittany. Our own impression is that these tumuli are not of an extreme antiquity—they do not belong to a very barbarous population, but to one which has made advance in social progress, and has attained to about the social condition of the Anglo-Saxons, a little before they entered Britain, or of the Icelanders in the time of Burnt Njal. They belong probably to the Britons of the South-West, from no very remote period before the Roman period to some time after the establishment of the Roman power, and were the burial-places of the patriarchal heads of families of importance, where, probably, generation after generation was interred. Such barrows are not found in the central and then more barbarous parts of the island, because they were held by the older populations, while these districts had received an immigration of more civilized peoples. In Scilly they are called giants' graves—a common popular name for anything ancient. In its simplest form, the receptacle of the dead in these tumuli is a mere square chamber, an expansion of the idea of the ruder cromlech, though more elaborately built; in its more enlarged character it took the form of a great subterranean gallery, as at Bolleit and Pendeen, in Cornwall. The chamber of the barrow at Pennance, in the parish of Zennor, described by Mr. Blight, is nine feet six inches in length, by four feet in width, and four feet four inches high. It is constructed in that bold sort of Cyclopean masonry which has prevailed in Cornwall down to the present day, the more massive stones forming the basement of the walls. That of the end of the chamber is formed almost entirely of one single slab. The roof consists of large slabs of granite thrown horizontally across from wall to wall. This chamber lay in a direction from north-west to south-east, the entrance being from the north-eastern end, where there was no wall, and access was easily obtained by clearing away a part of the side of the mound. This mound is twenty-three feet in diameter, and eight feet in height. It is bounded by a circle of retaining stones, some of them of large dimensions, and is filled up with stones chiefly, mixed with some earth, piled around and over the cell. No remains were found in the chamber, or cell, of this barrow, which has been the case with others of the same class, probably in consequence of the depredations of people who, at some perhaps remote period, opened them in search of treasure. Mr. Blight describes the opening, at which he assisted, of two other Cornish barrows, on Conquer

Down, in the parish of Towednack, both composed of stones—cairns, in fact—and bounded by a circle of larger stones. One was forty-five feet in diameter, and six feet in height, and covered only one interment, consisting of a very rude urn, containing the ashes of the dead; it had been placed exactly in the centre—which was placed with the mouth downwards, on a large slab of granite, and was protected by another slab of granite placed over it. It was the common practice in these barrows, which antiquaries have called British, to place the urn with the mouth downwards. The urn, which is preserved not quite entire, is of the usual character found in this class of barrows, but of a form not very common, being not quite perfectly barrel-shaped. It is of coarse clay, of a light greyish brown colour, and has been sun-dried; it is ornamented round the upper rim with four lines of dotting, and the well-known zigzag pattern deeply impressed between them. The other barrow was smaller, for it measured thirty-six feet in diameter, and only four feet in height; but it was of the same form and materials. There was no urn, or regular interment, but in the centre were found traces of burning, some bones of animals, and the half of a flint pebble, which had been artificially broken.

At a recent meeting of the Ethnological Society (June 7th), the Swedish Professor Nilsson communicated a paper on Stonehenge, which excited some interest. His theory is that this remarkable monument of antiquity belongs to the bronze period, a bronze period of his own (Professor Nilsson has published a book on it), which he regards as having been introduced by the Phœnicians, and he supposed the date of Stonehenge to be about four thousand years before Christ. According to the doctrines of this school of antiquaries, the Phœnicians had established themselves not only in every part of Britain, but even in the remotest parts of Scandinavia, and they must have formed a very important part of the population. Professor Nilsson ascribes to these Phœnicians New Grange, in Ireland, and similar monuments, as well as the monuments known as cromlechs, Druidical circles, etc., wherever they are found in the British islands. In this paper, Professor Nilsson shows an extraordinary want of critical appreciation of facts and arguments, for he assumes that a certain supposed Phœnician inscription found in Scotland, and exhibited at the Cambridge meeting of the British Association, where the blunder about it was satisfactorily exposed, is still a genuine monument of the Phœnician occupation of Britain. It is a very remarkable circumstance that this presumed presence of the Phœnicians in Britain rests upon no foundation whatever—that no ancient writer known to us has ever said that they were here, and that no ancient monument points to their presence here. The very writer who has been quoted in proof of the visits of the Phœnicians to Britain, Strabo, says just the contrary, for he makes the Cassiterides, the island from which he pretends that the Phœnicians obtained their tin, a different place from Britain, and more distant from the continent of Europe, and that the opinion which identifies them with the Scilly Islands is a mere blundering guess is evident, for the

Scilly Islands are not few in number, like the Cassiterides, and no tin was ever found in them. According to Diodorus Siculus, who wrote at the same time as Strabo, that is, about half a century before Christ, the tin of Britain was carried to the Mediterranean through Gaul, and perhaps the Cassiterides islands was a name without any truth—a fiction of the Carthaginians, to conceal their commerce in tin along the coasts of Spain and Portugal, if the story of the ship being watched by the Romans and voluntarily wrecked, be not itself a mere legend. It would, indeed, be strange, if our islands had been so much frequented by the Phœnicians, that Diodorus, proverbial for his careful research and great historical knowledge, Julius Cæsar, who was especially interested in the metallic produce of Britain, and Tacitus, who had inquired particularly into the ethnological history of our island, should never have heard of them. It is our belief that the Phœnicians were never in Britain. The facts probably are that the tin mines of Cornwall were opened by settlers from Gaul, and perhaps from Spain, and that the Phœnicians had obtained tin in these countries, and monopolized the trading before it was carried over to Marseilles.

With regard to CROMLECHS and DRUIDICAL CIRCLES, which Professor Nilsson ascribes to Phœnician workmanship, there are circumstances which seem to show that they are by no means necessarily of the extreme antiquity which some people would give to them; and we would call attention to one record especially, which, we believe, has not been noticed by antiquaries. Among the ecclesiastical laws of the Anglo-Saxons, there is one code entitled "The Laws of the Northumbrian Priests," which appears to belong to the ninth or tenth century (*after* Christ), and which contains some provisions against practises of Paganism then existing. One of these laws forbids people making a frith-geard round a tree, or a stone, or a fountain, all which three we know were objects of superstitious worship among the Anglo-Saxons. The words of the original, literally translated, are, "If there be a frith-geard on any one's land, about a stone, or a tree, or a fountain, or any folly of that kind, then let him who made it pay the penalty of the breach of law." The word frith-geard, literally peace-yard, means simply a sacred inclosure, exactly such as was contained within that circle of stones which has been so often called Druidical, for a circle is the natural form of a small inclosure of space. The circle round the sepulchral tumulus marked the space belonging to the dead, within which nobody was allowed to trespass irreverently; the circle round the object of worship limited the space into which none but the priest was admitted. We look upon this law as showing not only that the circles of stones did not always belong necessarily to sepulchral interments, but that the construction of them was continued to so late a period as that of the compilation of these laws. Trees, to have become an object of worship, were probably ancient at the time the circles were raised round them, and have necessarily decayed and perished long ago, and accordingly we not unfrequently find circles of stones with no object remaining in the interior; circles of stones, with a single

upright stone in the centre, are not at all uncommon; and we have ourselves seen in North Wales a fountain which had a "Druidical circle" round it. This curious law, therefore, assures us that it would be very unsafe to assume that all circles of stones have belonged to sepulchral monuments, or that they are prehistoric in date, or even older than Saxon times. This must have some weight even on the question of the antiquity of Stonehenge, the only objects met with in which that have characteristics of date are fragments of pottery found under two of the large upright stones on their fall, and stated to have been distinctly Roman. It must be borne in mind that "Roman" in our Western antiquities means objects belonging to the Roman period, and continuing in use during several subsequent generations.

To return to the subject of CROMLECHS, it may be well to remark that, in the new number of the *Archæologia Cambrensis*, Mr. Blight, of whom we have spoken above, has given an account, with engravings, of a very curious monument of this description, standing at Llansantffraid, near Conway. It consists of a rather fine specimen of the ordinary cromlech, an immense block of stone, calculated to weigh nearly twenty-five tons, supported on what appears to have been originally about a dozen upright stones, forming the walls of a chamber, measuring eight feet from east to west, by seven from north to south, and averaging about three feet and a-half in height, so that its dimensions were not much different from the more elaborately-built chamber in the Cornish barrow at Pennance. But the peculiarity of this cromlech consists in two upright stones, raised on the outside on more elevated ground (for it stands on the side of a bank), which had evidently been placed there symmetrically for some purpose at which we cannot now even guess. A stone lying flat on the ground a little further off appears to be all that remains of a circle which inclosed the sacred ground of the cromlech, and probably formed the basis of a mound. This communication from Mr. Blight is followed by a paper on cromlechs in Pembrokeshire, written by the Rev. H. Longueville Jones, the founder of the Cambrian Archæological Association, long one of its most zealous and enlightened supporters, and the editor of its journal. Mr. Jones has given a description, with engravings, of four very remarkable cromlechs at Newton, Manorbeer, St. David's Head, and Pentre Ifan, all well worthy of a visit from the numerous excursionists who now turn their steps to South Wales. They are all remarkable for the size and weight of the flat stone which covers them. In the first of those we have mentioned, that of Newton, the supporting stones at one end have fallen, and the cap-stone remains with one end upon the ground. At St. David's Head, the cromlech stands outside of an ancient camp, or entrenched work, and the circle of stones remains which once defined the limits of the covering mound. That at Pentre Ifan is one of the largest cromlechs in Wales. When it was visited by the Cambrian Archæological Association in 1859, five persons on horseback stood within it, and under the capstone, at the same time. In this instance the existing cromlech seems to have formed one of several sepul-

chral chambers, once covered by a common mound, as traces of the others are found around it. It has been suggested to excavate in the interior of these monuments, but it may be doubted if this would lead to discoveries of any importance, for, whatever were the remains interred in it, they were, no doubt, laid on the floor at its present level, and were swept away when it was uncovered and opened by ignorant people who could not appreciate them.

It is sometimes necessary, in the interests of science, to repeat the simple explanation of words which people persist in misunderstanding. Such is the case with the word CELT, applied, not very properly, to an ancient implement in bronze or stone. Writers on what is called prehistoric archæology are constantly using this word, under the impression, apparently, that it has some special relation to these implements, and also to the people to whom they have been ascribed, and some even go so far as to call them *kelts*, as in a recently published work now before us. The facts of the case are these:—In the year 1709, Ralph Thoresby, the Yorkshire antiquary, communicated to the equally well-known antiquary, the dull, but industrious and painstaking writer, Thomas Hearne, some examples of these implements in bronze. Now Hearne found a word, *celtis*, of late or merely technical Latinity (it is not found in the dictionaries of pure Latin), signifying a chisel, or some tool of that kind, and he wrote a dissertation, printed in the first volume of his edition of *Leland's Itinerary*, to prove that these peculiarly-formed bronze implements were the *celtes*, or chisels, of the Romans. Antiquaries during the last century appear to have agreed quietly in this interpretation, and the name *celt* has thus been unwisely adopted for the bronze implements, and very absurdly transferred to implements in stone. In fact, Thomas Hearne was probably quite wrong. The Roman *celtis* appears to have been an instrument for cutting inscriptions. Ducange explains the word as meaning *cælum sculptorium*, and quotes an ancient inscription found in Rome, which describes the stone on which it was written as being the work of the mallet and *celtis*—

"MALLEOLO ET CELTE LITTERATUS CILEX."

The instruments to which our antiquaries have given the name of *celts* were certainly not made for engraving inscriptions in flint. It is clear that the word is wrongly applied, and ought to be abandoned.

We are now approaching the season when archæological and other societies hold their ANNUAL MEETINGS, or CONGRESSES, in the country, and we may look for new contributions to our archæological knowledge. The British Archæological Association will meet in the city of Durham, under the presidency of the Duke of Cleveland. The meeting will commence on the 20th of August. The Archæological Institute proposes to hold its meeting at Dorchester, on the 1st of August, under the presidency of the Marquis Camden. The Cambrian Archæological Association will hold its meeting this year at Douglas, in the Isle of Man, beginning with the 21st of August.

T. W.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

ANTHROPOLOGICAL SOCIETY.—*June* 6.

THE RACES OF ESKIMO LAND.—Dr. Berthold Seemann, in a paper on our knowledge of the races of the Arctic region, remarked on the desirability of extending our information with regard to their geographical range, as the question has still to be answered how near to the North Pole have human beings taken up their abode? The Eskimo, who are the most Arctic people known, are also one of the most widely-spread races on the globe; they extend from Greenland to the Aleutian Islands, living almost entirely on the produce of the chase, and clothing themselves with the furs of the wild animals they have slain. The personal experience of the author leads him to regard the western Eskimos as far superior to those of the eastern district, a difference that he traces to the low summer temperature of the eastern side of the most northern part of America. This produces a stunted vegetation, and consequent poverty of animal life; hence there is a more precarious and irregular supply of food, and consequently both the physical and mental development of the human races are arrested. Dr. Seemann described the Eskimo as generally destitute of any religion; they believe in the existence of good and evil spirits who inhabit the earth, sea, and air, but place them all on a footing of equality. Their marriage customs are very singular. When a man has made choice of the girl he wishes to marry, he proceeds to her mother, and asks for her hand; if the mother is satisfied that he can support a wife by his pursuit of hunting and fishing, she gives her consent, when the bridegroom obtains a complete suit of clothing, and offers it to the bride, who takes it to her home, and on returning to the bridegroom dressed in it, is considered as his wife. Infidelity is very rare, but polyandry exists to some extent, apparently among the less wealthy individuals.

GEOGRAPHICAL SOCIETY.—*June* 12.

VISIT TO THE WAHABEE CAPITAL OF ARABIA.—Colonel Lewis Pelly, political resident at Bushire, described his recent journey to the Wahabee territory, in company with Dr. Colvill and Lieutenant Dawes. They started on the 18th of February, and entered the country at the Port of Kowait, in the north-west corner of the Persian Gulf, and proceeded in a S.S.W. direction over the desolate unpeopled waste which separates the coast settlements from the well-peopled and cultivated highlands, or *Nejed*, of Central Arabia. The party did not attempt to conceal their nationality, although they found it prudent to throw the *abbah* and *chiffeeah* of the country over their own clothing. They travelled on camels, starting each morn-

ing a little before daybreak, and continuing the march until sunset. Their astronomical observations were taken at night, when the Arab attendants were asleep; and for this purpose they planted their tent with the entrance open to the North star. Soon after leaving Kowait all traces of road cease, and the Wahabee territory commences with boundless, gently-undulating plains, which in this early spring-time were slightly sprinkled with grass and flowers. Snakes, lizards, and insects abounded, but no human habitation was seen until they reached *Nejed* Proper, and only a single tree and one group of wells. The physical character of the country was varied by a series of seven ridges of sand hills, which lay parallel to each other and to the shore-line of the Persian Gulf, and which the party again crossed when returning by another route. They extend over many degrees of latitude, and are separated by narrow valleys; but there is, independently of this, a gradual general rise of the country from the seaboard towards the north-west. After ten days' march across these sandy ridges and narrow valleys, the party saw before them a boundless plain called Ormah, sprinkled here and there with brushwood. Wells and running streams were met with, but the latter soon terminate in the arid country to the east and west. The Ormah district is bounded on the west by a remarkable ridge, through a picturesque gap in which the road leads into Shaab, an upland plain a few miles in width, bounded by the Aridh hills, which are succeeded on the north by the Towaij chain, the two being separated by the well-peopled plain of Mehmeel. The cultivated and populous district of Sedeyr is a strip of land lying immediately under the Towaij range. The first town they entered in the centre table land was Sidoos, a cheerful, neat-looking place, embosomed in date-groves, where they were well received and invited to turn Mussulmen. They then turned eastward towards Riadh, the Wahabee capital, arriving fifteen days after their departure from Kowait. Colonel Pelly had three interviews with the Amir or Wahabee ruler, who is both the spiritual and temporal head of the Wahabee territories, and in all respects absolute throughout his dominions. The Amir was a man of exceeding dignity and self-confidence. He treated the British Envoy throughout with respect, and explained that the Wahabee empire was cut off, by the physical character of the country, from external relations; consequently he could have no foreign relations, nor did he wish for any, especially with the English. He claimed for the Wahabees the credit of having saved the Mahommedan religion from falling off from its original purity, and proposed to Colonel Pelly that he should become a Mahommedan. As far as the chief himself was concerned, Colonel Pelly believed that no obstacle would be placed in the way of a scientific exploration of the country, but the persons who surround him would be likely to present the greatest difficulties, on account of their intense bigotry and hatred of foreigners. The party returned to Okair, on the shores of the Persian Gulf, by way of El Ahsa district, a fertile oasis, from 20 to 30 miles in length by 12 in width. The longitude of Riadh is 46° 41′ 48″, the latitude 24° 38′ 34″.

NOTES AND MEMORANDA.

A Water Barometer in a Thunderstorm.—The following description of the action of a water barometer during a terrific thunderstorm at Birmingham, on July 8th, is by Mr. Alfred Bird, of that town. The fall of rain was unprecedented, and a storm of thunder and lightning raged from 1h. to 3h. p.m., which sacrificed one life in Birmingham, besides doing much damage to property at Balsall Heath, Wednesfield Heath, Wolverhampton, and other places:—"Mr. A. Bird, of Worcester Street, has a water barometer fixed upon his premises, and the action of the storm upon it was of a most remarkable description. In a barometer of this kind the water rises 13½ inches for every inch on the ordinary mercurial barometer, and the action is, therefore, most distinct. When the storm commenced the column of water stood at 389 inches, which would be equal to 29½ on the ordinary barometer. As the storm progressed, the oscillations in the water were from half an inch to an inch, and at nine o'clock in the evening, the barometer stood at 391½, and was then steadily rising. At every flash of lightning there was an instantaneous fall of the column of water from a quarter to half an inch, and then a gradual rise as the rain came on. The movements were remarkably interesting. When the electric disturbance had ceased, the column of water gradually rose, indicating that the density of the atmosphere was steadily increasing. This water barometer is, we believe, the only one in existence in the county at present." The instantaneous fall of the column of water from a quarter to half an inch at every flash of lightning is remarkable, corresponding apparently to sudden jumps of an electrometer, observed in thunderstorms. The column of fluid in a barometer is balanced as delicately as the gold leaves in a gold leaf electrometer. Being attracted by the free electricity in the atmosphere, it is not impossible that it might oscillate in a similar manner. At every flash of lightning a certain quantity of free electricity suddenly disappears, and the column of water is instantaneously let fall. If this be a true explanation of the phenomenon, the water barometer, in which the movements are greatly magnified, is at one and the same time a barometer and an electrometer. The distinctive character of the storm illustrates the great increase of electric tension with the magnitude of the fall of rain. The rain-fall in this instance amounted to 1·53 inch in two hours, a quantity only common between the tropics, and fortunately of very rare occurrence in our latitudes. A particular form of aneroid by Mr. Browning, described in Intellectual Observer, vol. vi., p. 38, would, as pointed out by us, probably be the most convenient instrument for testing these questions. We should much like to see one of these instruments suitably placed.

Comparative Luminosity of Venus and the Moon.—M. Chacornac has been able to carry out in the neighbourhood of Lyons a plan of measuring the relative intensity of the light reflected by equal surfaces of Venus and the moon. He employs an apparatus for double refraction and polarization, to which we have before alluded, and his experiments were made on the 20th June, at three a.m., when Venus and the moon were in conjunction. With a magnification of 70, the extraordinary image of Venus was visible in all its outlines, when only one two-thousandth of its light was permitted to reach the eye. Under these circumstances the dimensions of the planet were noticeably diminished, as M. Chacornac had previously found with reference to Jupiter. A brilliant portion of the moon, between the craters Rocca and Eichstadt, S.E. of Grimaldi, was selected for comparison, and it was found that the greatest reflecting power of the moon was only a tenth of that possessed by Venus. M. Chacornac could not detect any trace of polarized light in Venus, though it is very noticeable in the moon, and he considers that the light we receive from Venus is reflected from a continuous surface of clouds, and that the spots seen on her disc was not permanent, as De Vico supposed.

Sun Spots and Jupiter Spots.—M. Chacornac has kindly sent us engravings of equatoreal spots seen on Jupiter at half-past eight and half-past nine p.m., October 13th, 1856, in order to show their resemblance to sun spots (also engraved) seen at

noon on October 24th, 1864. The Jupiter spots are arranged conformably with the equatoreal winds of that planet, and the sun spots appear in like manner influenced by the rotation of that luminary. We have in a former number given an account of M. Chacornac's views regarding the sun spots as indications of eruptive action, and he thinks the Jupiter spot of October 13 "the probable result of a jet of vapour from a volcano reaching up into the region of clouds."

AIREY ON A POLAR EXPEDITION.—The Astronomer Royal writes a letter to the President of the Geographical Society, proposing that the new expedition should be towards the South Pole instead of the North. He points out the importance of observing the transit of Venus in 1882 from a good southern station, and recommends a previous investigation of the coast between Sabrina Land and Repulse Bay. So eminent an authority as the Astronomer Royal ought to be favourably listened to by the Government, and the information which he desires should be obtained; but we cannot see the slightest reason for putting the projects in competition. For geographical and other purposes no approximation towards the South Pole could possibly diminish the desirability of reaching the North Pole. As Mr. Markham showed in the excellent paper we recently published, the expense and risk of such expeditions are both trifling, and for a country that is in the habit of flinging away millions in experimenting, often rashly, with ships and guns, to refuse fifty thousand pounds for a couple of scientific expeditions is neither wise nor truly economical.

A NEW ANEMONE.—Mr. Gosse describes in the *Annals of Natural History* a new anemone, the *Ægeon Alfordi*, discovered by the Rev. D. P. Alford, M.A., Chaplain of the Scilly Isles. It has a red basal disc and pea-green column, suffused with purple, and the whole covered with red dots so minute as to be distinguished only by the aid of a lens." The column of the genus *Ægeon*, formed by Mr. Gosse to receive its one known species, the *Æ. Alfordi*, is "longitudinally fluted, as if composed of a multitude of slender vertical cylinders placed side by side. Each cylinder studded with a single vertical row of minute warts. No suckers or loop-holes. The tentacles are numerous in several rows, and scarcely retractile, those of *Æ. Alfordi* being of a lustrous green, each bearing a faint line of grey along its outer side. When fully expanded it is sometimes 4 inches in height by 1½ in diameter. At other times it will be 2 inches in each direction. Expanse of flower 6½ inches. It possesses a wonderful tenacity of life, and does well in an aquarium." Mr. Gosse's specimen was sent to him by post on the 4th of April. On the 12th he received notice from the post-office that it could not leave Plymouth till repacked, as sea-water was exuding from the tin case. This was accomplished, but the creature did not reach Mr. Gosse till the 17th, and then manifested its vitality by soon adhering and expanding in all its beauty.

LAWSON ON THE OPTICAL ADJUSTMENT OF THE EYE.—Dr. Lawson publishes a very important paper in the *Ophthalmic Review*, No. 5, on the accommodation power of the eye. He controverts the theory commonly adopted (without proof), on the authority of Helmholz and others, that the crystalline lens is rendered more convex for near vision, and less so for distant vision. Dr. Lawson points to the absence of any anatomical evidence that such action can take place, and he disputes the conclusiveness of certain optical experiments from which it has been assumed. A careful examination of the eye of an emu convinced Dr. Lawson that the ciliary muscle had no attachment to the ciliary processes or to the lens, and he observed that the ciliary muscle was so placed that its contraction must alter the form of the cornea. He argues that if such a mode of focussing the eye is provided in the case of the emu, it is probably so with man. Dr. Lawson further contends that the experiments of Helmholz are consistent with his theory of the action of the eye. The subject is too technical for us to pursue it at length, but we think Dr. Lawson invalidates the opinions that have been usually received, and he substitutes an explanation so probable as to deserve the most careful and candid investigation.

ARTIFICIAL FECUNDATION OF GRAIN CROPS.—In a former number we gave an account of M. Hooibrenck's plan of artificially distributing the pollen of grain crops by sweeping over them when in flower strings having tufts of wool attached

to them. M. Camille Schnaiter details in *Cosmos* some fresh experiments, in which the gain of this process appeared to be about 15 per cent. Repeated trials are, however, necessary in such a case.

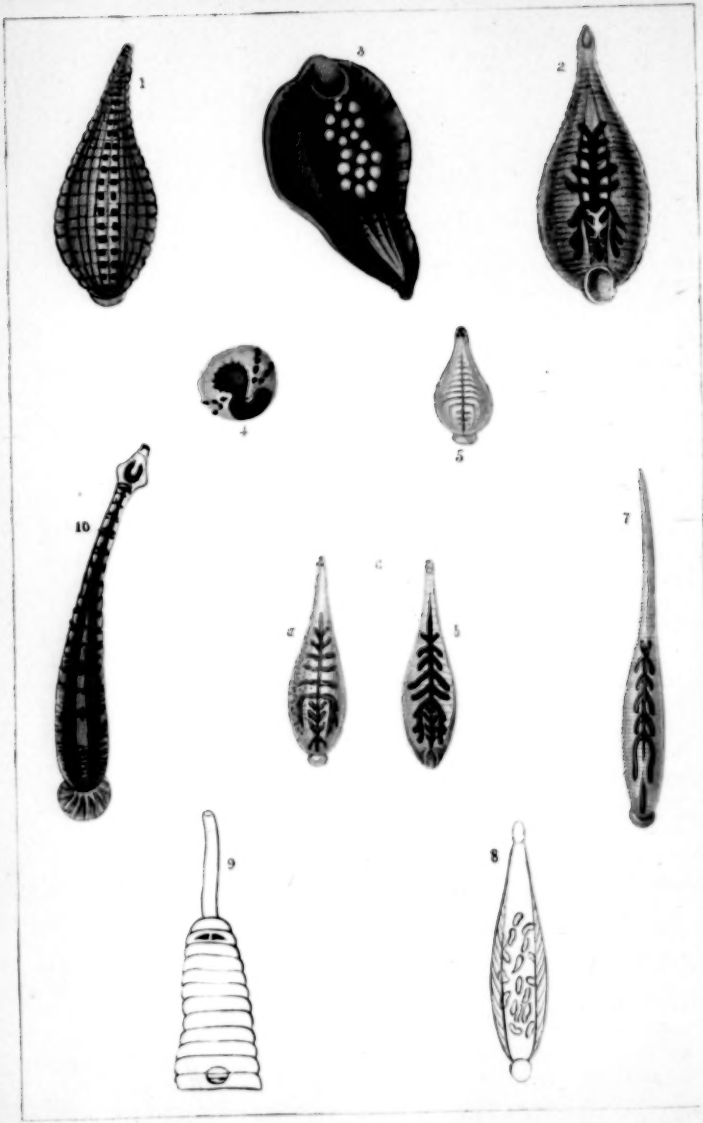
Remarkable Thunderstorm in France.—M. Camille Flammarion states in *Cosmos* that on the 8th of June at Huy (Meuse), a shepherd and his flock were struck by lightning. Out of 152 sheep 142 were killed, and the sheepdog could not be found. The lightning fell like a rain of fire over a space of more than 15 mètres.

Gas Works and Respiratory Disorders.—We mentioned in a former number that a French physician recommended whooping-cough patients to inhale the exhalations of the purifiers in gas-works. A commission now reports to the French Academy that the medicative action may be obtained by placing 60 or 70 grammes of the "brown ammonia," obtained from gas works, on a plate, and allowing it to evaporate in the chamber of the patient. They report it as useful in many respiratory disorders.

New Patent Bubble Blower.—Three years ago, when the subject was quite new, we gave an account of Plateau's films and bubbles (see vol. i., p. 309). Messrs Myers, of Berners Street, have now imported a neat little apparatus, adapted to blowing the large and comparatively permanent bubbles which were so much admired for their magnificent colours when first exhibited in this country by Dr. Frankland. A globular tin vessel is partly filled with the soap compound—oleate of soda and glycerine—described in the notice above alluded to. By pressing the thumb upon an India-rubber valve closing the mouth of this vessel a sufficient quantity of the compound is thrown up into a little cup, below which a flexible tube enters. On blowing steadily through the tube, a fine bubble may be formed, and detached with facility. This apparatus is neater and easier to manage than a tobacco pipe, and if Messrs Myers sell the soap compound properly prepared, they will no doubt popularize M. Plateau's beautiful experiments.

Collins's Dissecting Microscope.—Mr. Collins has made for Dr. Lawson a very convenient dissecting microscope. It consists of a small neat mahogany box carrying dissecting instruments, and having, instead of an ordinary stage, a gutta-percha trough to which the object to be dissected can, when necessary, be pinned, and covered with water. When transparent illumination is required, the object can be brought over a glass disc let into the trough, and placed over an adjustible mirror, by which light from a natural or artificial source can be thrown up. The magnifiers are binocular and fitted to a sliding adjustment. Dr. Lawson finds that when both eyes are employed, and the object well-illuminated, very small parts can be dissected with a slight magnifying power, and in the present apparatus two convenient wrist supports draw out, one on each side. This form of instrument is excellently adapted to the average wants of students, and amateur preparers of microscopic objects. It would also do well for botanical investigations.

Improved Warrington's Microscope.—Mr. Collins has improved the admirable portable microscope devised by Mr. Warrington, by converting the lid of a small oblong mahogany box into the stand, and giving two grooves for the stage to be fixed in, so as to be in its right position at different angles to which the instrument may be inclined. Mr. Collins has also made an addition that will be exceedingly welcome to possessors of aquaria and large glass cells. He fixes the Warrington microscope to the glass by means of a pneumatic holder, which is instantly attached or detached. Thus fixed, and furnished with a two or a four inch power, the habits and proceedings of the inhabitants of glass tanks or cells can be very conveniently watched. Every possessor of an aquarium should have a microscope of this sort. The object-glasses having the universal screw will work with any other microscope, and the Warrington microscope in its present form is by no means expensive.



SNAIL LEECHES.

Glossiphonidæ.

1-4, Glossiphonia complanata.
5-6, G. hyalina.
7-9, Glossiphonia bioculata.
10, G. marginata. All magnified.